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ADDITION AND RENOVATION

PACKAGE D – ADDITION AND RENOVATION

The University of Alabama, Tuscaloosa, Alabama

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STATE OF ALABAMA
KPS GROUP, INC.
3531
By DONALD C. SIMPSON
REGISTERED ARCHITECT

K|P|S
GROUP
Architecture Interior Design Planning Urban Design
60 14th Street South, Suite 100, Birmingham, Alabama 35233
Tel (205) 251-0125 · kpsgroup.com ·

DOCUMENT 00 01 07

PROFESSIONAL SEALS

ARCHITECT

The following Sections:

Divisions 00 - 33 Sections, except where indicated as prepared by other design professionals of record, were prepared by **KPS Group, Inc.**

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CIVIL ENGINEER

The following Sections were prepared by **Duncan Coker Associates:**

01 20 20 UTILITY SURVEYS BY CONTRACTOR

02 21 02 EXISTING UTILTIES
02 41 16 SITE DEMOLITION

31 10 00 SITE CLEARING
31 20 00 EARTH MOVING
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32 12 17 MILLING OF EXISTING ASPAHLT PAVING
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32 13 13 CONCRETE PAVING
32 13 20 CONCRETE CURB, GUTTER, AND SIDEWALKS
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STRUCTURAL ENGINEER The following Sections were prepared by **MBA Engineers, Inc.:** **01 41 00** SPECIAL INSPECTIONS **03 30 00** CAST-IN-PLACE CONCRETE **05 12 00** STRUCTURAL STEEL FRAMING **05 31 00** STEEL DECK **31 66 15** HELICAL FOUNDATION PILES	

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MECHANICAL ENGINEER

The following Sections were prepared by **HHB Engineers, PC:**

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22 14 29	SUMP PUMPS
22 34 00	CONDENSING DOMESTIC WATER HEATERS
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MECHANICAL ENGINEER

The following Sections were prepared by **HHB Engineers, PC:**

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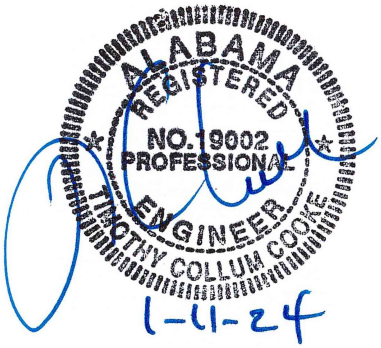
ELECTRICAL ENGINEER The following Sections were prepared by **Jackson Renfro & Associates, Inc.:** **26 05 00** BASIC ELECTRICAL MATERIALS AND METHODS **26 05 19** POWER CONDUCTORS AND CABLES 51V-600V **26 05 26** GROUNDING **26 05 33** RACEWAYS **26 05 34** OUTLET BOXES, JUNCTION BOXES, WIREWAYS **26 05 53** ELECTRICAL IDENTIFICATION **26 05 73** POWER DISTRIBUTION SYSTEM ELECTRICAL STUDIES **26 09 43** LIGHTING CONTROL SYSTEM **26 09 44** DISTRIBUTED DIGITAL LIGHTING MANAGEMENT SYSTEM **26 24 16** POWER PANELBOARDS - CIRCUIT BREAKER TYPE **26 24 17** LIGHTING PANELBOARDS **26 27 13** ELECTRICAL METERING **26 27 26** WIRING DEVICES **26 28 13** FUSES **26 28 16** SAFETY SWITCHES AND FUSES **26 32 13** GENERATOR SETS **26 36 23** AUTOMATIC TRANSFER SWITCHES **26 36 33** GENERATOR LOAD BANK DOCKING STATION **26 41 00** LIGHTNING PROTECTION SYSTEM **26 43 00** SURGE PROTECTIVE DEVICES **26 50 00** LIGHTING MATERIALS AND METHODS **27 05 00** AUXILIARY SYSTEM CABLES, 0-50V **28 31 00** FIRE ALARM SYSTEM	

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LANDSCAPE ARCHITECT The following Sections were prepared by **Renta Urban Land Design:** **32 13 13** CONCRETE PAVING **32 14 00** UNIT PAVING **32 84 00** PLANTING IRRIGATION **32 91 13** SOIL PREPARATION **32 92 00** TURF AND GRASSES **32 93 00** PLANTS	 11 JAN 2024

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SECTION 211313

AUTOMATIC SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. NFPA 13, 2019 edition.

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Sprinklers.
3. Alarm devices.
4. Pressure gages.
5. Standpipe system specialties

1.3 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Wet-pipe or dry-pipe sprinkler system piping designed to operate at working pressure of 175 psig (1200 kPa) maximum.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

B. Standard-Pressure Sprinkler Piping: Sprinkler system piping designed to operate at working pressure of 175-psig (1200-kPa) maximum.

C. Manual Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections and has small water supply to maintain water in standpipes. Piping is wet, but water must be pumped into standpipes to satisfy demand.

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Available flow test records are indicated on the plans, Delegated designer to verify.

C. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications – As indicated on the plans.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated.

B. If electronic submittals are used, provide Adobe File with bookmark for: Equipment; Piping; Heads; Calculations; and Drawings.

C. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

D. Delegated-Design submittal: for sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation.

E. Coordination drawings: sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Domestic water piping.
2. HVAC Ductwork
3. HVAC Hydronic piping
4. Items penetrating finished ceiling included the following:
    a. Lighting fixtures.
    b. Air outlets and inlets

F. Qualification Data: For qualified Installer and professional engineer.

G. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

H. Welding certificates.

I. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

J. Field quality-control reports.

K. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Nicet Level III Technician Responsibility: Preparation of working plans, calculations, and field test reports by a qualified Nicet Level III Technician.

b. All Calculations and Plans shall be reviewed, signed, and stamped by a Professional Engineer licensed in the State of Alabama.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.8 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by

NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS – WET PIPE SYSTEM

A. Standard-Weight, Black-Steel Pipe: ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Thinwall Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

C. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.

D. Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

E. Steel Couplings: ASTM A865/A865M, threaded.

F. Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

G. Malleable- or Ductile-Iron Unions: UL 860.

H. Cast-Iron Flanges: ASME 16.1, Class 125.

I. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick EPDM rubber gasket.

    a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
    b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.

J. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

K. Grooved-Joint, Steel-Pipe Appurtenances:
1. Pressure Rating: 175-psig (1725-kPa) minimum.
2. Painted Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).

B. Iron OS&Y Gate Valve:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Clow Valve Company; a division of McWane, Inc.
   c. Crane Co.; Crane Valve Group; Crane Valves.
   d. Crane Co.; Crane Valve Group; Jenkins Valves.
   e. Crane Co.; Crane Valve Group; Stockham Division.
   f. Hammond Valve.
   g. Milwaukee Valve Company.
   h. Mueller Co.; Water Products Division.
   i. NIBCO INC.
   j. Tyco Fire & Building Products LP.

2. Standard: UL 262.

3. Pressure Rating: 250 psig (1725 kPa) minimum.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

C. Indicating-Type Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International, Inc.
   b. Global Safety Products, Inc.
   c. Kennedy Valve; a division of McWane, Inc.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Tyco Fire & Building Products LP.
   g. Victaulic Company.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Valves NPS 2 (DN 50) and Smaller:

   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.

5. Valves NPS 2-1/2 (DN 65) and Larger:

   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged, grooved, or wafer.

6. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch and visual indicating device.

2.5 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 psig (1200 kPa) minimum.

B. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves
   c. Fire Protection Products, Inc.
   d. Kennedy Valve; a division of McWane, Inc.

e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Potter Roemer.
i. Tyco Fire and Building Products LP.
j. Victaulic Company.
k. Watts Water Technologies, Inc.

2.6 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:

1. Standard-Pressure Piping Specialty Valves: 175-psig (1200-kPa) minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International, Inc.
b. Conbraco Industries, Inc.; Apollo Valves
c. Fire Protection Products, Inc.
d. Kennedy Valve; a division of McWane, Inc.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Potter Roemer.
i. Tyco Fire and Building Products LP.
j. Victaulic Company.
k. Watts Water Technologies, Inc.

2.7 HOSE CONNECTIONS

A. Adjustable-Valve Hose Connections:
1. Standard: UL 668 hose valve, with integral UL 1468 reducing or restricting pressure-control device, for connecting fire hose.
2. Pressure Rating: 300-psig (2070-kPa) minimum.
3. Material: Brass or bronze.
4. Size: NPS 1-1/2 or NPS 2-1/2 (DN 40 or DN 65), as indicated.
5. Inlet: Female pipe threads.
6. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads in accordance with NFPA 1963 and matching local fire-department threads.
7. Pattern: Angle or gate.

8. Finish: Polished chrome plated.

2.8 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International, Inc.
    b. National Fittings, Inc.
    c. Shurjoint Piping Products.
    d. Tyco Fire & Building Products LP.
    e. Victaulic Company.

2. Standard: UL 213.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AGF Manufacturing Inc.
    b. Reliable Automatic Sprinkler Co., Inc.
    c. Tyco Fire & Building Products LP.
    d. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Elkhart Brass Mfg. Company, Inc.
    b. Fire-End & Croker Corporation.
    c. Potter Roemer.

2. Standard: UL 199.
3. Pressure Rating: 175 psig (1200 kPa).

4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. AGF Manufacturing Inc.
   b. Triple R Specialty.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.
   e. Viking Corporation.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Flexible Sprinkler Hose Fittings:
1. Standard: UL 1474.
2. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: 175-psig (1200-kPa) minimum.
4. Size: Same as connected piping, for sprinkler.

2.9 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFAC Inc.
2. Globe Fire Sprinkler Corporation.
3. Reliable Automatic Sprinkler Co., Inc.
4. Tyco Fire & Building Products LP.
5. Venus Fire Protection Ltd.
6. Victaulic Company.
7. Viking Corporation.

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
4. Intermediate temperature in all food preparation kitchens, electrical rooms, boiler rooms, and AV-IT rooms.

D. Sprinkler Finishes:

1. Chrome plated.
2. Bronze.
3. Painted.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Plastic, white finish, one piece, flat.
2. Sidewall Mounting: Plastic, white finish, one piece, flat.

F. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Reliable Automatic Sprinkler Co., Inc.
    b. Tyco Fire & Building Products LP.
    c. Victaulic Company.
    d. Viking Corporation.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.10 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Fire-Lite Alarms, Inc.; a Honeywell company.
    b. Kennedy Valve; a division of McWane, Inc.
    c. Potter Electric Signal Company.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.11 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK; U.S. Gauge Division.
2. Ashcroft, Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

D. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's existing interior water-distribution piping.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Contracting Officer before deviating from approved working plans.

B. Piping Standard:
1. Comply with requirements for installation of sprinkler piping in NFPA 13.
2. Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install alarm devices in piping systems.

K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

M. Fill sprinkler system piping with water.

N. Install sleeves for piping penetrations of walls, ceilings, and floors.

O. Install sleeve seals for piping penetration of concrete walls and slabs.

P. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

J. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

K. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.
3. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

3.7 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install NPS 1-1/2 (DN 40) hose-connection valves with flow-restricting device.

D. Install NPS 2-1/2 (DN 65) hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40) reducer adapter and flow-restricting device.

E. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

3.8 HOSE-STATION INSTALLATION

A. Install freestanding hose stations for access and minimum passage restriction.

B. Install NPS 1-1/2 (DN 40) hose-station valves with flow-restricting device unless otherwise indicated.

C. Install NPS 2-1/2 (DN 65) hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40) reducer adapter and flow-restricting device unless otherwise indicated.

D. Install freestanding hose stations with support or bracket attached to standpipe.

E. Install wall-mounted, rack hose stations in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

F. Install hose-reel hose stations on wall with bracket.

3.9 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13 and NFPA 14, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Verify that equipment hose threads are same as local fire-department equipment.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.12 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-pressure, wet-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be the following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:

1. Standard-weight black-steel pipe with cut grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
2. Thinwall black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-pressure, wet-type fire-suppression standpipe piping, shall be the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

3.13 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Upright Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

C. Medium temperature in all food preparation kitchens, electrical rooms and AV-IT rooms.

END OF SECTION 211313

SECTION 220000

PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General Provisions of the Contract, including General and Special Conditions, and Division 1 - General Requirements, apply to the work specified in this Section.

B. Excavation and backfill, DIVISION 2.

C. Painting, DIVISION 9.

D. Toilet Room Accessories, DIVISION 10.

E. Electrical, DIVISION 26.

F. All parts of this Section of the Specification take precedence over other sections of Division 22 and 23 (in connection with Plumbing work) unless noted otherwise.

G. Comply with Section 230000 with it in its entirety, including “PRIOR APPROVAL” requirements.

H. Circuit Setters, Section 232116 Hydronic Piping Specialties.

I. Insulation, Section 230719 Mechanical Piping Insulation

J. Domestic Hot Water Generating System, Section 223400 Condensing Domestic Water Heaters

1.2 DESCRIPTION OF WORK

A. The work to be performed under this Section of the work shall consist of but is not limited to the following general categories.

1. Provide complete and operable plumbing systems to serve all plumbing fixtures, equipment, hose bibbs, air conditioning equipment, etc.

1.3 SCOPE

A. The plumbing system for this work includes all cold water distribution, domestic water heating and distribution, vents and wastes, floor drainage, natural gas distribution, plumbing fixtures and trim, connection of equipment furnished by others, assisting the other trades in the connection of the gas equipment to the gas supply and the fuel oil storage system. All other items indicated on drawings or described in these

specifications, and all other plumbing items needed for a complete and proper installation. (See "General Conditions" and "Scope of Work", and "Mechanical General Provisions" which is a part of this contract.)

1.4 QUALITY ASSURANCE

A. General: Provide all new materials, labor, tools, equipment, transportation, incidentals and services necessary for the complete installation in every respect and the satisfactory operation of the plumbing systems as specified below and as shown on the drawings.

B. Contractor shall verify conditions and check all measurements at job site.

C. Wherever the word "supply", "provide" or similar term is used in the sense of providing apparatus or materials, it shall mean that Contractor shall furnish and connect such apparatus or materials referred to, unless otherwise specifically called for, at no additional cost to Owner.

D. All statements made throughout these Specifications shall be considered as orders, directives, instructions, etc., to the Contractor to whom this Contract is awarded whether the word "Contractor" is used or not, unless otherwise noted.

E. Insulation of piping does not protect pipe against freezing. All water bearing pipe must be run on the heated side of the building insulated envelope or provided with heat trace. If heat trace is required, and none is shown, the contractor shall provide heat trace, as well as all power circuits and controls, as work of this project and without additional expense or change order to the contract.

F. Codes, Permits:

1. Obtain and pay for all permits and inspections required by all laws, ordinances, regulations, and public authority having jurisdiction. The following codes, standards and regulations in effect on the date of bid invitation shall be considered a part of this specification:

    a. State Public Health Department Regulations
    b. International Code Congress (ICC) Codes
    c. Local and State Plumbing Codes
    d. National Fire Protection Association
    e. American Society of Mechanical Engineers
    f. American Society for Testing Materials
    g. Underwriters' Laboratories'
    h. National Electrical Manufacturers Association
    i. OSHA - Occupational Safety and Health Standards
    j. Local Utilities' Requirements

2. All material and workmanship shall comply with all latest applicable sections of local, municipal, parish or county, state, federal, industry and utilities company’s rules, regulations, codes, ordinances and standards. Pipe sizes shown are minimum that will be allowed.
3. Should the Contractor perform any work that does not comply with the requirements of the applicable codes, standards and regulations, he shall bear all costs arising from the deficiencies.
4. Deliver copies of all certificates of inspection to Architect for delivery to Owner upon completion of the work.
5. Do not conceal any work until it has been inspected and tested.

6. Terminology used in these specifications is that of the ICC International Plumbing Code (IPC).
7. Should work shown on these drawings and specifications be located in any area which levies a SEWER USE FEE or surcharge, this cost shall be included in the Contractor's bid unless specifically omitted by instructions in the General or Special Conditions.
8. Should local utility require any payment or fee for providing water or gas service to the facility, the cost shall be included in Bid.
9. All applications required shall be filled in the Owner's name.
10. Should work shown on the Contract Documents not be as strict as "local interpretations" of the local code, the Contractor shall make his bid in accordance with the local requirements and shall call the Architect's attention to the changes required to comply with the above.
11. Inspections: Obtain and pay for all inspections, required by all laws, ordinances, rules, regulations, or public authorities having jurisdiction. This Contractor shall obtain and pay for all certificates of such inspections, and file such certificates with the Owner.
12. Contractor shall be a licensed plumbing locally.

G. Drawings and Specifications:

1. Drawings and Specification are complementary to each other. What is called by one shall be binding as if called for by both.
2. All methods of construction, details of workmanship and detailed arrangement of all work where not specifically described herein or indicated on the drawings, shall be subject to the control and approval of the Architect.
3. Architect shall render a decision in writing as to the space allotment in congested areas, which decision shall be binding on all. No claims for "extras" due to such decisions will be allowed, even though the work has already been installed.
4. Submit shop drawings for review on all fixtures, equipment and accessories.
5. It shall be the responsibility of the Contractor to use the Contract Document Drawings and these Specifications for a basic layout of the Plumbing Systems. Contractor shall not be permitted to change this basic method of distribution of the system details without submitting drawings for review and acceptance before fabrication and installation, and in particular with reference to exposed piping.
6. Plumbing drawings are diagrammatic; see Architectural drawings and building for dimensions and conditions not shown. Drawings do not show all fittings or details, but must be followed generally. Changes must be approved in writing. Obtain Architect's written decision in case of doubt as to intent of drawings or specifications. Failure to obtain written decision will leave this contractor liable for damage to work of other trades and responsible for corrections required by Architect.
7. Plans and Riser Diagrams (Risers): Plumbing Plans and Risers are complementary to each other. What is called for by one shall be binding as if called for by both. Where pipe sizes differ from the plans to the risers, it shall be considered as a drafting inaccuracy and the larger of the sizes shall be provided.

1.5 RESPONSIBILITY OF THE CONTRACTOR

A. Contractor shall examine all drawings, specifications, addendums, and the Site of the work. He should familiarize himself with the character of work, coordination required with other trades, and any conditions that affect the completion of this work. No consideration will be given at a later date for any alleged misunderstanding as to the requirements, materials to be furnished, or any special requirements due to the nature of the job site or local conditions.

B. Items obviously omitted from the plans and specifications shall be called to the attention of the Architect before bidding. After the award of the contract, any changes, additions, or rearrangements necessary to complete the work as outlined shall be at this Contractor's expense.

C. The utilities shown are based on the best information available to the Designers and is for Bidding purposes and indication of desired routing only. The Contractor is required to coordinate with the required utilities prior to entering Bid, and Bid so as to include all costs of obtaining utilities as required by the drawings.

1.6 SUBMITTALS

A. See paragraph on Submittals in Section 230000 including processing time required to be provided to the Engineer.

B. All submittals shall be electronic. Submittal shall be in Adobe PDF format with each individual specification section bookmarked to allow for easy access to specific items. Specification sections to have nested bookmarks for each item/major piece of equipment covered by that specification.

C. Submit for review complete data, cutsheets, capacities, type, and grade for review of fixtures, trim, pipe, insulation (jackets and fittings), and all other major components. Submit within 30 days of signing of general contract. Submit all items at one time with a cover sheet identifying all items submitted. Partial submittals will be rejected.

D. Where plumbing fixtures are specified by manufacturer name and model, and a substitution manufacturer and model fixture is proposed, the submittal shall include a cross reference guide published by the manufacturer actually specified indicating that the proposed fixture and manufacturer is an appropriate substitution. In such cases where no such cross reference is published, provide cut sheets for both the specified fixture and the proposed fixture to facilitate evaluation by the Engineer.

E. Reviews will be returned to the general contractor with comments, or reason for rejection. Resubmit at once on rejected items.

F. Materials, fixtures, or equipment installed without review or after rejections shall be replaced by this contractor with acceptable items at Architect's direction.

G. The supplier, by submitting, certifies that his materials and/or equipment are satisfactory for the application for which they are proposed.

H. Contractor agrees that submittals processed by the Engineer are not change orders; that the purpose of submittal by the contractor is to demonstrate to the Engineer that the contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and materials he intends to furnish and install and by detailing the fabrication and installation methods he intends to use.

I. Contractor further agrees that if deviations, discrepancies or conflicts between submittals and specifications are discovered either prior to or after submittals are processed by the Engineer, the design drawings and specifications shall be followed.

1.7 COORDINATION DRAWINGS

A. Prepare coordination drawings which fully coordinate the location and interface requirements (due to spatial limitations and constraints) of the work including Architectural, Structural, Fire Suppression (Protection), Plumbing, HVAC, Electrical, Owner furnished equipment, etc. to eliminate construction conflicts. This requirement is fully the responsibility of the Contractor and these drawings shall not be submitted for review but shall be maintained at the jobsite and updated as necessary to prevent conflicts. The designers shall assume, as a result of receiving and reviewing other required submittals, that this coordination has be accomplished, that these drawings have been made and kept up to date, and no other consideration shall be given for construction interferences which may arise.

1.8 WORKMANSHIP

A. Work to be orderly, neat, workmanlike in appearance, done by skilled craftsmen. Any work not so installed shall be removed and replaced without additional cost to owner or Design Professionals.

B. Work shall be first class and in accordance with best practice. Pipe shall be cut clean, properly reamed, threaded or soldered, erected plumb and secure. Make changes in pipe size with reducing fittings.

C. At all stages of installation, protect pipe openings, fixtures, and equipment against the entrance of foreign materials.

1.9 SAFETY

A. Perform all work in a safe manner. Protect all workmen and others on site. Barricade (light if necessary) all ditches, holes, openings through floors and other hazards. Comply with all health and safety regulations. Contractor is solely responsible for job site safety.

1.10 COOPERATION

A. Cooperate with all crafts; schedule work as needed; do not delay other trades; maintain necessary competent mechanics and supervision on the job at all times.

1.11 INCIDENTAL WORK INCLUDED

A. Cutting of structure (patching to be done by the affected trade at this contractor's expense). Secure Architect's approval where strength or appearance is affected.

B. Necessary foundations not shown on Architectural or Structural plans.

C. Motors, controls, control devices, control wiring, all as required for a complete system shall be by this contractor unless shown on the electrical drawings and included in that section. All electrical work shall comply with the Division 26 Electrical sections of the specifications.

D. All ferrous metal exposed to weather shall be prime coated with a primer to match the metal and finished with a two coat application of finish paint of color and type selected by the Architect. Where the finish painting

is specified in the section on painting, the two final coats may be omitted, but the metal shall be prime coated before rusts starts to form.

1.12 QUESTIONS AND CLARIFICATIONS

A. Contractor shall not rely on any verbal clarification of the drawings and specifications. Any questions shall be referred to the Architect/Engineer at least seven (7) working days prior to the bid date to allow clarification by addendum. After seven days prior to bidding, the bidder shall make his own decision and, if necessary, qualify his bid.

1.13 AS-BUILT DRAWINGS

A. Furnish a reproducible set of "AS BUILT" drawings showing dimensional location of pipes, cleanouts, etc. at the time of final review of the job.

1.14 QUALIFICATIONS

A. Contractor shall have at least three (3) years of successful installation experience on plumbing work similar in size and scope to this project.

1.15 CHANGES

A. If during construction desirable or necessary changes become apparent, advise the Architect and secure his decision in writing; otherwise make no deviation from the system as detailed.

1.16 CLEARING AND ADJUSTING

A. Upon completion of work, clear all drains, traps, pipe lines, and plumbing fixtures. Adjust all valves, pack stuffing boxes, remove rubbish and leave work in clean and operating condition.

1.17 FOUNDATIONS

A. Provide foundations, supports, etc., not specified under other sections and as required to mount equipment in a workmanlike and structurally sound manner. Consult drawings pertinent to other trades to determine extent of their work.

1.18 TEMPORARY SERVICE

A. Contractor shall be required to install permanent water and gas supply at the points indicated on the drawings by connecting to the permanent service line. Any temporary lines extended from the permanent service line shall be provided at the expense of The Contractor.

1.19 ELECTRICAL PROVISIONS OF PLUMBING WORK

A. All electrical work required in association with the Plumbing work (in order to provide complete operating systems) shall generally be a part of the Division 26 work. However, there are certain portions of the electrical requirements which shall be a responsibility of the Division 22 work, which shall be executed in accordance with applicable Division 26 Specification requirements. Refer to 23 01 00 Paragraph 2.4 for additional requirements related to electrical work integral to the Plumbing work. The electrical provisions of Plumbing work, where it may be furnished integrally with mechanical work, can be summarized (but not by way of limitation) to include the following:
   1. Control cabling and raceways associated with the hot water heater system. Provide all required sensor cable from tank to water heater master controller and between the two water heaters. Senor cables must installed in raceway with appropriate junction boxes for final sensor cable terminations.
   2. Low voltage interlock wiring from each water heater to its associated pump.
   3. Motor starters for water heater pumps, comply with 21 01 00 paragraph 2.4.
   4. Electric heat tracing cable with terminations at heat trace controller. Coordinate power circuit to controller with Division 26 contractor.
   5. Sump pump control cables and terminations at control panel.
   6. Coordinate power location for Digital Recirculation Mixing Valve.

B. Responsibility: It is the sole responsibility of the Contractor to coordinate the electrical requirements of each item of equipment provided with the electrical circuits required and to insure their compatibility and compliance with the N.E.C.

1.20 GUARANTY

A. All piping, equipment, fixtures, and related material shall be guaranteed in writing against defective materials and workmanship for a period of one year from date of acceptance. After notification, corrections shall be made promptly at no cost to the owner. Any defects due to faulty materials, equipment, method of installation or workmanship, and consequent damage resulting from such defects within the one-year guaranty period, shall be repaired or replaced promptly upon notice and without any expense to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. All products shall comply with the applicable sections of the Plumbing Code in effect in the building location. Where bidder is not sure, he is advised to determine what limitations, if any, are imposed at the site. All bids are assumed to be on approved material. Bidders/Contractors shall not use a lesser material than that specified even if allowed by code at the building site.

B. Lead-Free Requirements:

   1. Any product designed for dispensing potable water must meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
   2. This requirement supersedes specific model numbers stated either in these specifications or on the drawings, should a non lead-free model number be specified for products designed for dispensing potable water.

C. For ease of maintenance and part replacement, and to the maximum extent possible, use equipment of a single manufacturer. The Architect reserves the right to reject any materials list which contains equipment from various manufacturers if suitable equipment can be obtained from fewer manufacturers, and to require source of materials to be unified to the maximum extent possible.

D. All materials and equipment installed in HVAC return air plenums shall have a 25/50 flame spread/smoke developed index maximum when tested in accordance with ASTM E 84.

E. All products shall be new, of first line quality of grade and type shown on the drawings and specified, or equals accepted by the Architect/Engineer in writing.

F. All products shall be in current production with no notice having been given that such product is to be drastically changed, modified, or discontinued from production.

G. The supplier, by submitting, certifies that equipment being processed is proper for the application intended and that it has the capacity specified.

2.2 MATERIALS

A. Building Soil, Waste, Storm and Vent Piping:
1. Service weight cast iron, bell and spigot, conforming to ASTM A74 as manufactured by AB&I, Charlotte, or Tyler, with lubricated rubber compression joints conforming to ASTM C1563**.**
2. Above ground: Cast iron no-hub system, manufactured by AB&I, Charlotte, or Tyler, with neoprene gasket conforming to ASM C564, type 302 stainless steel shield and four clamp (pipe sizes 4” or less) or six clamp (pipe sizes larger than 4”) heavy-duty stainless steel clamps, equal to Ideal Tridon Super heavy-duty HD or Anaco Husky SD 4000.
3. All cast iron soil pipe, fittings and clamps shall conform to the requirements of CISPI Standard 301, ASTM A-888 or ASTM A-74 and be marked with the collective trademark of the Cast Iron Soil Pipe Institute. All pipe and fittings shall be certified and marked NSF.
4. Stub-out to fixtures shall be made with Schedule 80 galvanized steel pipe for urinals and DWV copper tubing and fittings or Schedule 80 galvanized steel for other fixtures.

B. Sump Pump Discharge:

1. Type "L" copper tubing, hard drawn.

C. Hot and Cold Piping (Inside Building):

1. Underground: Use Type "K" copper, soft drawn; in tunnels: use Type "K" hard drawn; ASTM B-88, with wrought copper fittings ANSI B16.22. Join underground or in tunnel fittings with silver solder AWS-ASTM BCUP-5. Pipe below floor slabs shall have joints made by looping up in wall out of the slab, no joints under the slab will be permitted.
2. Above ground: Use Type "L" copper tubing, hard drawn, with same fittings as specified above, joined with lead free 95-5 solder, ASTM B32 alloy, Grade 5A except for any special systems requiring temperatures higher than 250 degree F or pressures above 125 psi for which alloy E, alloy HB, or brazing materials shall be used. As an option, Viega ProPress jointing system may be utilized in accordance with all of the manufacturer’s recommendations for pressure pipe jointing.
3. Nominal pipe sizes are shown on the Drawings.

4. Copper tubing air chambers shall be provided at each fixture supply and piece of equipment and shall be line size and 18 inches in length. Provide manufactured water hammer arrestors where shown.
5. Use dielectric fittings at all dissimilar pipe connections.

2.3 INSULATION, ACCESSIBLE LAVATORIES

A. Application Requirements: Provide pre-formed vinyl plastisol snap-on insulation for traps, waste arm, tailpiece elbows, supply line and shut-off valve. Insulation to comply with ANSI and ADA requirements, Trap Wrap or equal.

2.4 VALVES AND COCKS

A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim, Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Flow Controls; Conbraco Industries, Inc.
    b. Jomar Valve.
    c. KITZ Corporation.
    d. Milwaukee Valve Company.
    e. NIBCO INC.

2. Description:

    a. Standard: MSS SP-110 or MSS SP-145.
    b. CWP Rating: 600 psig (4140 kPa).
    c. Body Design: Two piece.
    d. Body Material: Bronze.
    e. Ends: Threaded.
    f. Seats: PTFE.
    g. Stem: Stainless steel.
    h. Ball: Stainless steel, vented.
    i. Port: Full.
    j. Extended stems for all insulated piping.

B. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABZ Valve and Controls.
    b. American Valve, Inc.
    c. Apollo Flow Controls; Conbraco Industries, Inc.
    d. DeZURIK.
    e. Jomar Valve.
    f. KITZ Corporation.
    g. NIBCO INC.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating, NPS 12 (DN 300) and Smaller: 200 psig (1380 kPa).
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Extended steam for all insulated piping.

C. Drain valves shall be "NIBCO", #763, 3/4" size, with approved anchors from flange to walls or columns. Provide screw-on type backflow preventers.

D. Wall hydrants shall be as specified scheduled on the Drawings.

E. Valve boxes for valves in underground pipelines shall be cast iron type with removable cast iron lid cast with the service designation in it (example: “water”, “gas”, etc.).

2.5 ACCESS PANEL

A. Provide access to all parts requiring service such as valves, regulators, traps, water hammer arrestors, etc., and where shown. Access doors shall be of the size required to properly service the item, but generally not smaller than 12" X 12". Where access doors cannot be provided for structural or architectural reasons, this shall be called to the Architect's attention.

B. Access panels and doors shall have the same fire rating as the wall, ceiling, floor, or construction in which installed.

C. Access doors in painted areas shall be prime coated with finish painting under the Painting section.

D. In wet areas or areas with ceramic tile floors or walls, the access doors shall be stainless steel or nickel brass.

E. Access doors shall be provided with a concealed key operated lock and concealed hinges.

2.6 UNIONS

A. Use a union in the connection to each valve and each piece of apparatus equipment, so that it may be readily removable. In copper lines, up to and including 4" sizes, use cast brass or bronze unions, with copper soldered connections and ground joints.

B. Unions in drainage pipes on fixture side of traps may be slip or flanged joints with soft rubber or leather gaskets.

C. Unions 2" and smaller shall be ground joint type with flanges being used in pipes larger than 2".

2.7 CLEANOUTS AND EXTENSIONS

A. Cleanouts shall be cast iron bodies with brass plugs. They shall be extended full size to floors and wall faces, but shall not be larger than 4". Extension to floor shall be made with combination "Y" and eighth bends.

B. Provide cleanouts in sanitary, waste and drain lines as shown, as required by local Code, and as follows:
1. At the bottom of each exposed fixture trap which is not integral with the fixture.
2. At the end of each branch drainage line.
3. At each change of horizontal direction greater than 45 degrees.
4. At the base of each stack and in horizontal drain lines at intervals of not more than 50 feet apart in lines smaller than 4", 75 feet apart in lines of 4" nominal size, and 100 feet apart in lines larger than 4".

C. Install cleanouts so that they are readily accessible.

D. Cleanouts in interior floor construction shall be equal to Smith 4020 or 4040 (for floors with square tile), with scoriated cover, nickel-bronze finish. Cleanouts in walls and ceilings shall be as specified under "Access Panels".

E. Cleanouts at grade shall be provided with a 12” diameter by 4” thick monumentto allow for locating and turf grooming.

2.8 TRAPS

A. Traps for floor drains, hub drains, etc., shall be standard C.I.S.P.I. cast iron P-traps, with hub and spigot joints for lead caulking or no-hub systems coated with Coal Tar Varnish while hot, except traps for drains used in fan rooms, which shall be of similar type cast iron but deep seal P-traps having a minimum 4.75 inch seal.

B. Install ProSet Trap Guard or Jay R. Smith Quad Close Trap Seal devices in all floor drains.

C. Comply with trap requirements as specified for individual fixture type, in lieu as specified here, when specified differently for fixture type.

2.9 FLASHING

A. Flashing for soil and vent stacks passing thru roof shall be furnished under this Section of the Specifications.
1. Flashing for bituminous roofs shall be formed of minimum 4-pound sheet lead and shall be of thimble and counterflashing type. Base shall be made so that coverage of 12" plus the diameter of the boot is obtained. Height of flashing shall be sufficient to allow for ample turn-down into pipe.
2. Flashing for membrane roof and metallic roofs shall be in accordance with the roofing manufacturer’s recommendations.

2.10 SLEEVES AND ESCUTCHEONS

A. Provide galvanized sheet metal sleeve for all pipes at floors, ceilings, partitions; steel pipe sleeve two pipe sizes larger than pipe at walls and footings.

B. Sleeves in structural beams to be furnished by General Contractor at location set by this contractor.

C. Provide nickel plated escutcheons with spring lock or set screw at ceilings, floors, and walls for all pipes.

2.11 SHOCK ABSORBERS (WATER HAMMER ARRESTORS)

A. Shock absorbers shall be rated and sized by PDI Standards. Body of the unit shall be non-corrosive and non-toxic. Arrestors shall be mounted accessibly above the ceilings or shall be provided with access panels in the ceilings or wall above or behind the fixture which they are installed.

2.12 SUPPORTS, ANCHORS, AND SEALS

A. Types of supports, anchors, and seals specified in this article include the following:

1. Horizontal-Piping Hangers and Supports.
2. Vertical-Piping Clamps.
3. Hanger-Rod Attachments.
4. Building Attachments.
5. Saddles and Shields.
6. Miscellaneous Materials.

B. QUALITY ASSURANCE:

1. MSS Standard Compliance:

a. Provide pipe hangers and supports of which materials, design and manufacture comply with ANSI/MSS SP-58.
b. Select and apply pipe hangers and supports, complying with MSS SP-69.
c. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
d. Terminology used in this article is defined in MSS SP-90.

C. SUBMITTALS:

1. Product Data: Submit catalog cuts, specifications, installation instructions, and dimensioned drawings for each type of support, anchor, and seal. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.

D. HORIZONTAL-PIPING HANGERS AND SUPPORTS:

1. General: Except as otherwise indicated, provide factory-fabricated horizontal-piping hangers and supports complying with ANSI-MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's

published product information. Select only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems.

2. Adjustable Steel Clevises: MSS Type 1.
3. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:

    a. Plate: Unguided type.
    b. Plate: Guided type.
    c. Plate: Hold-down clamp type.

E. VERTICAL-PIPING CLAMPS:

1. General: Except as otherwise indicated, provide factory- fabricated vertical-piping clamps complying with ANSI/MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.
2. Four-Bolt Riser Clamps: MSS Type 42.

F. HANGER-ROD ATTACHMENTS:

1. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with ANSI/MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Select only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.
2. Swivel Turnbuckles: MSS Type 15.

G. BUILDING ATTACHMENTS:

1. General: Except as otherwise indicated, provide factory-fabricated building attachments complying with ANSI/MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems.
2. Concrete Inserts: MSS Type 18.
3. Side Beam or Channel Clamps: MSS Type 20.
4. C-Clamps: MSS Type 23.
5. Side Beam Brackets: MSS Type 34.
6. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:

    a. Fee & Mason Mfg. Co., Div. of A-T- Inc.
    b. ITT Grinnel Corp.

H. SADDLES AND SHIELDS:

1. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
4. Thermal Hanger Shields: Constructed of 360° insert of high density, 100 psi, and waterproof calcium silicate, encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation.
5. Manufacturer: Subject to compliance with requirements, provide thermal hanger shields of one of the following:
   a. Elcen Metal Products Co.
   b. Pipe Shields, Inc.

I. HANGER RODS

1. Hanger Rods: Shall be all threaded rod and shall have the following diameters:

   a. 3/8" for up to 2" diameter pipe.
   b. 1/2" for 2-1/2" to 4" pipe.
   c. 5/8" for 5" and 6" pipe.
   d. 3/4" for 6" and 8" pipe.

2. Hanger Spacing: Shall be as followed (except not less than two hangers per length of pipe):

   a. Cast Iron pipe: 5'-0" spacing maximum and at each hub, on both sides of horizontal no-hub fittings, and at each trap.
   b. Steel Pipe: 6'-0" spacing up to 2" diameter and 10'-0" for 2-1/2" diameter and larger.
   c. Copper pipe: 6'-0" spacing up 2" diameter and 10'-0" for 2-1/2" diameter and larger.
   d. Plastic pipe: 4'0" for up to 2" diameter and 6'0" for 2-1/2" to 6" diameter, 10'0" for pipes larger than 6" diameter.

3. Hanger Locations in wood and light gage structures: No multiple hangers shall be permitted on a single building wooden or light gage steel member. Hangers shall be staggered to distribute loads evenly over the structure and additional longitudinal structural members provided to evenly distribute loads. Provide hanger locations as part of the required piping shop drawings.

J. MISCELLANEOUS MATERIALS:

1. Metal Framing: Provide products complying with NEMA STD ML 1.
2. Steel Plates, Shapes and Bars: Provide products complying with ANSI/ASTM A 36.
3. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.
4. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

2.13 FIXTURE HANGARS

A. Hangers for fixtures shall match the fixture and the wall construction and shall provide adequate support to prevent the fixture from pulling out of the wall or loosening from the wall.

B. Minimum hanger acceptable for lavatories, drinking fountains, and urinals is the plate system equal to Zurn Z-1259.

C. Hangers for wall hung toilets shall be the chair carrier type suitable for use with fixture provided.

2.14 WATER PRESSURE-REDUCING VALVES

A. Water Regulators (PRV-):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Honeywell Water Controls.
    b. WATTS.
    c. Zurn Industries, LLC.

2. Standard: ASSE 1003.

3. Pressure Rating: Initial working pressure of 150 psig.
4. Design Inlet Pressure: see plans.
5. Design Outlet Pressure Setting: see plans.
6. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.15 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:

    a. Strainers NPS 2 and Smaller: 0.020 inch.
    b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
    c. Strainers NPS 5 and Larger: 0.10 inch.

6. Drain: Factory-installed, hose-end drain valve.

2.16 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Individual-Fixture, Water Tempering Valves:
1. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Body: Bronze body with corrosion-resistant interior components.
4. Temperature Control: Adjustable.
5. Inlets and Outlet: Threaded.
6. Finish: Rough or chrome-plated bronze.
7. Tempered-Water Setting: see plans.

B. Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Armstrong International, Inc.
c. Cash Acme; a division of Reliance Worldwide Corporation.
d. Leonard Valve Company.
e. Symmons Industries, Inc.
f. WATTS.

2. Standard: ASSE 1017.

3. Pressure Rating: 125 psig.
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 105 deg F.
9. Tempered-Water Design Flow Rate: 0.5 gpm.
10. Valve Finish: Chrome plated.

C. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Armstrong International, Inc.
c. Cash Acme; a division of Reliance Worldwide Corporation.
d. Lawler Manufacturing Company, Inc.
e. Leonard Valve Company.
f. Symmons Industries, Inc.
g. Zurn Industries, LLC.

2. Standard: ASSE 1017.

3. Provide thermostatic controller with integral check stops, removable cartridge with stainless steel piston and thermal motor or bimetallic thermostat. Standard rough bronze finish. Max pressure 125 psi. Provide thermometer on outlet, cut off valves on inlet and outlet. For systems with hot water circulating pumps (for temperature maintenance) a by-pass from the "pump discharge/heater cold water inlet" to the mixing valve "cold water inlet" shall be provided with a check valve.

4. Pressure Rating: 125 psig minimum unless otherwise indicated.
5. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
6. Material: Bronze body with corrosion-resistant interior components.
7. Connections: Threaded union inlets and outlet.
8. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
9. Tempered-Water Setting: see plans.
10. Valve Finish: Chrome plated.
11. Piping Finish: Copper.

2.17 WATER SYSTEM ACCESSORIES

A. Circulating pump shall be in-line, horizontal system, lubricated type with bronze or stainless steel body. Pump to have stainless steel shaft supported by carbon sleeve bearings. Bearings to be lubricated by the circulating medium. Pump to be bronze fitted Bell and Gossett Series 80 or approved equal by Armstrong.

B. Aquastat controller shall have adjustable setpoint with remote bulb strapped to hot water return line, Honeywell L6006 or equal.

2.18 FLOOR DRAINS

A. Floor drains shall be the size of the pipe to which they are connected. Install temporary closures during construction. Each drain shall have deep seal P-trap.

B. Floor drains shall be equal to the J. R. Smith figure numbers as scheduled.

C. Floor drains shall have "Trap Guard" devices as manufactured by ProSet Systems, Inc., or Jay R. Smith Quad Close Trap Seal.

2.19 ROOF DRAINS:

A. Roof Drain: J.R. Smith 1010 with underdeck clamp and 4" cast iron dome.

B. Emergency (overflow) Drains: J.R. Smith 1070 with underdeck clamp, cast iron standpipe, and cast iron dome.

C. Down Spout nozzle: J.R. Smith 1770, nickel-bronze, suitable for wall mounting.

D. Scupper Drain: J.R. Smith 1560 or 1570, cast bronze body with combined rough bronze grate and flashing clamp and gasket. Refer to plans for 90-deg or 45-deg threaded outlet locations.

2.20 EQUIPMENT FURNISHED UNDER OTHER SECTIONS

A. Equipment indicated below is to be furnished and set in place under another Section of these Specifications (or is to be provided by the Owner). Verify exact size and locations of vents, waste and supply connections from approved rough-in drawings and/or catalog cut sheets. All water and gas connections are to be provided with stop valves.

B. HVAC Equipment: Provide gas supplies with stop valve to within two (2) feet of equipment connection. Provide water line with backflow preventer for chilled and hot water make-up water shown on the plans. Provide vacuum breaker in humidifier make-up. Terminate water supply within two (2) feet of point of connection. Coordinate with HVAC contractor to insure service will be at proper location. Final connection to equipment will be specified under the HVAC Sections of these Specifications. Provide pressure reducing valves at all equipment requiring reduced pressure service.

PART 3 - EXECUTION

3.1 UTILITY SERVICES

A. General: All work shall be done in accordance with the best practices and al products installed as directed by the manufacturer through his written instructions.

B. Utility connections:

1. Connect to exterior utilities provided by other sections of these specifications.

C. Excavations and Backfill

1. Do all excavation and backfilling required. Trenches shall be wide enough for proper installation of the pipe. Grade the ditch bottom for proper slope and provide bell holes to allow the full bearing of the pipe barrel. Comply with all health and safety regulations relating to the work.
2. Excavate rock 6" below the pipe and fill with sand up to the pipe grade.
3. No excavation shall be done under or near footings without approval of the Architect.
4. Where the ditch is under future pavement, finish surfaces, or footings, the fill shall be compacted in 6" layers with a power tamper.

D. Pipe and Fittings

1. Install all domestic water soil, waste and vent, and storm piping generally as shown on drawings, with no deviation from diagrammed arrangements. If in any instance it is impractical to install piping as shown, or should approving agencies demand other arrangement, notify Architect in writing along with a diagram of proposed changes for Architect's approval, and said agencies' approval, all at no additional cost to Owner.
2. Carefully plan work to avoid existing utilities and other interferences. Architect and his Consulting Engineers have not attempted to indicate all existing utilities and other interferences. Prior to doing any plumbing work, carefully investigate and locate all existing conduits, pipes, and other utilities

3.2 WATER DISTRIBUTION PIPING

A. Extend from the termination of the water service to every fixture, water heater, or outlet requiring hot or cold water. Provide stop valve and a drain for the system. Every low point shall be drained with a drain valve.

B. Every fixture connection shall be provided with a stop valve.

3.3 BUILDING DRAIN, WASTE, AND VENTS

A. Building drain terminates into the building sewer shown above approximately five feet outside the building line.

B. The Waste and Vent system shall be generally as shown on the drawings with changes on the job as required to meet the job conditions. Any major change from that shown on the drawings shall be approved by the Architect.

C. All pipe shall be supported in a manner such as to prevent excessive stress

D. The bottom of all stacks shall be washed by a fixture whether required by local code or not.

E. Extend vent stacks 12" above the roof and flash with lead flashing furnished by this contractor and installed into the roof by the roofer. Top of flashing turned into the stack by this contractor.

F. There shall be no horizontal offset in vents less than 6" above the flood rim of the highest fixture in the group.

G. For plastic waste or vent pipes passing through floor penetrations or fire rated wall assemblies, a manufactured penetration complying with ASTM E-814-09 shall be utilized with and intumescent element capable of sealing off the penetration in the case of pipe failure. This shall include all floor penetrations including pipe, water closet bends, bathtub drains, floor drains, etc. Penetrations shall be equal to Proset System “C”.

3.4 TESTING

A. Notify Architect, Engineer and local authorities three working days before test are to be made. No joints or fittings are to be concealed until tested, and any defects shall be corrected by replacement with new materials. Retest until satisfactory.

B. Follow test as described in the 2021 edition of the ICC International Plumbing Code or as follows (whichever is most stringent):

1. Sewer System:
    a. Water Test - fill system with water (minimum of 10' head) and hold for 45 minutes without drop in water.
    b. Sewer Ball - pass wooden sewer ball through system using only water to wash through. Ball shall pass freely.
    c. Peppermint Test - seal all traps of fixtures and introduce peppermint into vent from roof. There shall be no odor in building.

2. Water System:
   a. Impose pressure of 150 psi; with system full of water, hold for 4 hours without pressure drop. If air pressure is used, hold pressure for 8 hours without drop except as temperature drops. Provide pressure gauge and leave in place.

3. Gas System:
   a. Low pressure side: Impose psi air pressure and hold for 4 hours. High pressure side: Impose a pressure of 100 psi and hold for 8 hours

3.5 STEEL PIPE SYSTEMS

A. Steel pipe fittings shall be screwed type using full cut threads. Use glycerin and white lead or Teflon tape. Use drainage pattern for waste and/or vent

3.6 CAST IRON PIPE SYSTEMS

A. Fittings of the no-hub, push type, or lead and oakum shall be installed as recommended by the manufacturer using tools as recommended by them. Take care to prevent shifting or settling of pipe.

3.7 SOLDER TYPE FITTINGS

A. Solder type fittings below a slab are prohibited. Loop pipe up in wall and make soldered joint or fitting.

B. All solder type fittings shall be made up using specified solder except for any special systems requiring temperatures higher than 250 degree F or pressures above 125 psi for which alloy E, alloy HB, or brazing materials shall be used. Clean pipe and fittings bright with sand paper or wire brush and apply paste flux (liquid flux is not acceptable) and assemble joint. Apply heat evenly to the pipe and fittings and apply solder to fill the joint by capillary action. Clean joint of excess solder before it cools. Fittings discolored by heat shall be removed and the joint remade.

C. The Architect or Engineer may require the cutting out and destructive testing of up to five joints of their own selection to determine the type of workmanship being performed and the 'fullness' of the solder in the joint. Such joints shall be remade by the contractor at his expense. Should the joints tested show large voids or other indication of poor joints, the workman making the joints shall be replaced and other joints tested to determine the extent of such problems.

D. Every connection between ferrous and non-ferrous metals in pipe, tanks, etc. shall be separated by a dielectric union or flange equal to Wedge Seal

3.8 LAYOUT

A. This contractors responsibility includes:

1. Setting of floor and wall sleeves in proper locations.
2. Informing other trades of location of and size of chases, stacks, cleanouts, etc., that will later relate to their work.

3. Providing access to all items requiring routine service.
4. Setting the elevation of the floor drain tops to provide for a slope of 1/16" per foot toward the drain. This requires coordination with the concrete subcontractor, the General Contractor and rechecking at the time the pour is being made.
5. Coordinating with the HVAC Contractor to insure that the actual equipment installation will not interfere with the mechanical room floor drain locations shown and that adequate clearance is provided for the routing of condensate drains to these floor drains.

3.9 HANGARS AND SUPPORTS

A. All pipe shall be supported in a manner such as to prevent excessive stress and variations in supporting forces onto the supporting forces onto the supporting structures. Anchor and hang in such a way as not to interfere with natural expansions and contraction and the anchors and guides shall be capable of withstanding such forces imposed on them by the expansion and contraction of piping.

B. All vertical piping extending from floor to floor shall be supported vertically at each floor with approved riser clamps and secured horizontally.

C. All pipe hangers shall be of sufficient size to allow for pipe insulation.

D. All insulated lines shall have supports for piping placed on outside of insulation at every support anchor or guide. Hangers shall not be in contact with the pipe. Saddles between hangers and insulation shall be galvanized iron shields.

3.10 GRADES

A. Pipe shall grade in direction of flow not less than the following

1. Building Sewer and Building Drain below slab - 1/4" per foot.

2. Building Sewer and Building Drain other than below slab - 1/8" per foot.
3. Waste and Vent 2-1/2" and smaller - 1/4" per foot.
4. Waste and Vent 3" and larger - 1/8" per foot.
5. Gas - 1/8" per foot.
6. Water piping shall be pitched to allow complete draining.

3.11 INSTALLATION OF PIPES

A. All threaded pipes shall be reamed to remove all cutting lips from the inside edge and shall be threaded with clean dies to the proper depth. Cuts shall be clean and not gouged or rough. Apply lubricant to male thread only.

B. All buried thermoplastic piping shall be installed per ASTM D2321.

C. All copper pipes shall be reamed to remove all cutting lips from the inside edge.

D. Pipe shall be laid or supported in a straight and true manner with fittings used to make all changes in direction.

E. Cutting and Patching:

1. No reinforcing steel in slabs, ceilings, roof, etc., shall be shifted or cut, nor will any structural members be cut or altered, without the specific approval of Architect unless the Contract Drawings show exact details for same. Do not make deep cuts into building framing without the specific approval of the Architect. Provide metal and/or timber reinforcing of joist, studs, plates, etc., where such cuts are made, as directed by the Architect.
2. Provide basic patching between masonry openings and sleeves, drains, cleanouts, etc., up to the finished surfaces, by sealing these openings with an approved non-shrinking grout, installed according to manufacturer's written instructions. The surface patching and finishing shall also be done under this section of the work in a manner as approved by Architect.
3. Where holes or cut-outs are made in flooring for the installation of drains, vents, etc., remove only enough concrete and reinforcing to install piping, etc. Preserve as much reinforcing steel as possible. Do not cut into grade beams or footings. Restore and add to floor reinforcing steel as directed by the Architect. Rebuild floor to original thickness and finish with non-shrinking 3,000 P.S.I. concrete.

F. Pipe Sleeves:

1. Each pipe passing through masonry and/or concrete construction shall be free from the structure and shall pass through a sleeve.
2. Each sleeve shall extend through its respective floor, wall, etc., and shall be cut to be flush with each outer finished surface, except sleeves in floors, which shall extend one inch above finished floor unless noted otherwise. Sleeves shall be Schedule 40 galvanized steel pipe.
3. Unless otherwise noted, the inside diameter of all sleeves shall be a minimum of one inch larger than the outside diameter of the pipe or conduit it serves, or a minimum of one inch in diameter larger than the outside diameter of the insulation on insulated lines.
4. All holes required in concrete or masonry structures shall be cored with a diamond bit core drilling machine. No holes shall be cored through beams, joists or columns. Every safety precaution shall be taken in coring holes to prevent electric shock should any energized circuits be encountered.
5. Caulk space full between sleeves and pipe or conduit, insulated or plain, above grade, to provide a positive smoke seal. Where holes have been cut in masonry for placing sleeves, the space between cut openings and sleeves shall be sealed as called for above under Paragraph "Cutting and Patching".
6. Where exposed piping passes through walls, ceilings, floors or partitions, provide chromium plated, pressed steel escutcheons, Crane 10B and C, or approved equal.

3.12 PLUMBING FIXTURES

A. Exact location of fixtures or equipment shall be as shown on Architectural drawings, as scheduled on the Plumbing drawings and as approved by Architect. Check Manufacturer's details of all roughing in.

B. Provide all necessary supports in connection with all fixtures to be installed. Fixtures shall not be supported by piping connections.

C. Install wall hangers and carriers by means of through bolts.

D. Caulk all around fixtures which mount tight to walls, floors or counter tops with "Dow Corning" No. 780 or General Electric "RTC" Silicon sealant.

3.13 CLEANING AND DISINFECTING

A. All potable water piping shall be flushed and disinfected prior to connection to domestic water supply. Disinfecting shall be carried out in accordance with State Sanitary Code and local regulations

3.14 BALANCING

A. Before final acceptance, fully balance all systems furnished under this Section to achieve optimum performance. Systems shall be free from water hammer

3.15 TESTS:

A. Make tight and test all piping, valves, fittings, specialties and equipment required by regulatory authorities.

B. Do not conceal any work until it has been tested and inspected. Notify Architect and proper authorities in ample time when any work is ready for inspection and testing.

3.16 PAINTING:

A. The painting of all material and equipment furnished and installed under these sections of the Specification shall be included as part of each trade of these Sections.

B. All surfaces to be painted shall be cleaned free of rust, dirt, grease, etc.

C. Paint all mechanical and electrical equipment (not considered as having an enameled or baked finish) and in areas exposed to view paint all piping, raw metal supports, hangers, bases and anchors.

D. Paint shall be Rustoleum, Koppers, Pittsburgh, or approved equal, of the best type recommended by paint manufacturer for the surface conditions where used.

E. The surfaces shall be prepared and the paint applied as per Manufacturer's written recommendations, with recommended number of primary and finish coats. Colors shall be selected by Architect.

F. See DIVISION 9 for other painting requirements.

3.17 ELECTRICAL:

A. All electrical work shown, noted and required to provide completely operating facilities shall be included as part of contract work.

B. Refer to DIVISION 26 - ELECTRICAL for materials and methods.

3.18 PROTECTION DURING CONSTRUCTION:

A. Install test plugs, wood plugs or caps in all open pipes at time of installation and do not remove until pipe is connected.

B. Maintain pressure and pressure gauge on all water lines during construction. Use water except in cold weather.

C. Drain all water from lines to prevent freezing.

D. Protect all finished surfaces of fixtures and brass from any damage. Fixtures or brass of any type that is damaged, scratched, discolored shall be removed and replaced at this contractor's expense.

3.19 FIXTURE HANGERS:

A. Lavatories shall be secured to a steel plate type hanger (or floor supported carrier when specified) imbedded in or secured to the wall in such a way that the fixture will be supported to the full extent of the strength of the wall. Provide a bolt from the plate hanger to the fixture carrier for each hole provided in the carrier.

3.20 START UP AND SERVICE:

A. Place all items installed under this division into operation and instruct the owner's maintenance personnel in all points requiring service and maintenance: make all adjustments and/or service requirements to equipment during the warranty.

3.21 VACUUM BREAKERS AND BACK FLOW PREVENTERS:

A. Install vacuum breakers above the highest piece of equipment to be protected. Location must be in area with floor drain, or provide other means of disposing of water that might drip out of vent opening. Vent may be piped to drain with use of air gap.

PART 4 - FIXTURES AND EQUIPMENT

4.1 GENERAL REQUIREMENTS

A. Furnish all plumbing fixtures, drains, and equipment as shown on the Architectural drawings. If architectural drawings differ from plumbing drawings, this shall be called to the Architect's attention before bidding.

B. Fixtures and other equipment shall be furnished complete with all trim, fittings, and other devices which are generally considered necessary by trade, by craft standards and/or the Architect.

C. Fixtures and equipment shall have the manufacturer's name or trademark imprinted on or attached by metallic name plate.

D. All fixtures and all trim may be of different manufacturer than fixtures, but equal to that specified. See Paragraph 1.6 for submittal requirements when submitting fixtures other than those specified and/or scheduled by name.

E. All exposed trim shall be chrome plated. Tops of all floor drains shall be chrome or nickel bronze unless otherwise noted

F. Furnish china or matching plastic bolt caps for all toilets and urinals.

G. Faucets, fittings, etc. scheduled on the Drawings are the catalog numbers of Zurn or as identified by name. This reference is for identifications of quality, and equal products of recognized manufacturers (ie: American Standard, Kohler, Symmons, Crane, Elkay, Oasis, Just Sinks, Toto, T&S Brass, JR Smith) will be accepted as equal if submitted with full catalog data and engineering data. Emergency Safety Stations shall be by Guardian, Bradley, or Acorn Safety.

END OF SECTION 220000

SECTION 221429

SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Submersible duplex elevator sump pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

A. Submersible, Duplex, Oil Detector Sump Pump System – For elevator:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Bell & Gossett Domestic Pump; ITT Corporation.
    b. Flo Fab inc.
    c. Goulds Pumps; ITT Corporation.
    d. Grundfos Pumps Corp.
    e. Liberty Pumps.
    f. Little Giant Pump Co.
    g. Stancor, Inc.
    h. Weil Pump Company, Inc.

2. Description: Factory-assembled and -tested sump-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced.
6. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
7. Seal: Mechanical.
8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

9. Controls:

    a. Enclosure: NEMA 250, Type 4X.
    b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
    e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

10. Controls:

    a. Enclosure: NEMA 250, Type 1; wall-mounted.
    b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.

d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

11. Control-Interface Features:

a. Remote Alarm Contacts: For remote alarm interface.
b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

1) On-off status of pump.
2) Alarm status.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and filling are specified in Section 312000 "Earth Moving."

3.2 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.3 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain pumps.

END OF SECTION 221429

SECTION 223400

CONDENSING DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes gas-fired, tank-type condensing water heaters, trim, and accessories for generating domestic hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

D. Other Informational Submittals:

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Water-Tube Condensing Water Heaters:

a. Leakage and Materials: 10 years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

G. Mounting Base: For securing boiler to concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 WATER-TUBE CONDENSING WATER HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AO Smith.
2. Camus
3. Laars Heating Systems Company.
4. Lochinvar, LLC (Basis of Design).
5. RBI

B. Description: Factory-fabricated, -assembled, and -tested, copper-finned, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

C. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.

D. Combustion Chamber: Stainless steel, sealed.

E. Tank: ASME Rated construction.

F. Burner: Natural gas, forced draft drawing from gas premixing valve.

G. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

H. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

I. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.

J. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.

K. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Textured epoxy.
4. Insulation: Minimum 1-inch- (25-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

2.3 TRIM

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.4 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Provide each motor with overcurrent protection.

2.6 VENTING KITS

A. Vent: PVC concentric vent kit.

B. Combustion-Air Intake: PVC, ducted to roof inlet.

2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:
   1. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

G. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify Architect 24 hours minimum in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 223400

SECTION 230000

MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. General: This section specifies several categories of provisions for mechanical work, including:

1. Certain adaptive expansions of requirements specified in Division 1, as uniquely applicable to mechanical work.
2. General performance requirements within the mechanical work as a whole.
3. General work to be performed as mechanical work, because of its close association with mechanical work.

1.3 SUMMARY OF MECHANICAL WORK

A. Drawings: Refer to the drawings for graphic representations, schedules and notations showing mechanical work.

B. Specifications: Refer to Divisions-21, 22, 23, and 25 sections for the primary technical specifications of mechanical work.

C. General Outline: The facilities and systems of the mechanical work can be described (but not by way of limitation) as follows:

1. Plumbing systems
2. Fire protection systems
3. Heating plants
4. Chilled water Pumps and distribution
5. Heating and air conditioning system
6. HVAC control system
7. Testing, Adjusting and Balancing.

1.4 SCOPE

A. This section shall consist of providing all materials, labor, tools, plant and incidentals necessary to install and make ready for owner's beneficial use, complete mechanical systems including a system of air

tempering for the proposed building as shown on the Drawings and called for in the Specifications. Completed Mechanical Systems means ready for operation, and that items omitted from drawings that are required for a complete and operational system will be furnished by the Contractor at no additional cost to the Architect, Engineer, or Owner.

B. It is understood that the responsibility for the work of the entire project falls upon one Contractor (sometimes, herein referred to as the General Contractor). The Designers, however, understand the relationship between the Contractor and other organizations, outside of his, which the Contractor employs to assist him with this work. The Division 23 Specifications are addressed to the Contractor and it is his responsibility to perform the work (regardless of whom he may employ for assistance). The Division 23 Specifications are written, however, in an effort to assist the Contractor with subcontract employment (herein referred to as "This Contractor", "Mechanical Contractor", "Electrical Contractor", "Plumbing Contractor", "Control Contractor", etc., or above listed as "Subcontractor" in lieu of "Contractor"). This shall not be construed by the Contractor to alleviate him of any responsibility for the work, including its coordination amongst various trades, and placement of the same on others, nor shall this be construed to direct the Contractor to the employment of Subcontractors (with the exception of Testing Agencies).

C. All references to "Contractor(s)" or "Subcontractor(s)" are referring to the Contractor and his coordination of responsibilities within the work of the Contract.

D. See the Architectural Plans and visit the site of work to observe dimensions, construction and details not shown on these Drawings.

E. Wherever the word "supply", "provide" or similar term is used in the sense of providing apparatus or materials, it shall mean that Contractor shall furnish and connect such apparatus or materials referred to, unless otherwise specifically called for, at no additional cost to Owner.

1.5 DRAWINGS AND SPECIFICATIONS

A. Consider as complementary each to the other. What is called for by one shall be binding as if called for by both. Where conflicts occur, obtain written clarification; otherwise provide the more expensive quality or quantity.

1.6 COORDINATION OF MECHANICAL WORK

A. General: Refer to the Division 1 sections for general coordination requirements applicable to the entire work. It is recognized that the contract documents are diagrammatic in showing certain physical relationships which must be established within the mechanical work, and in its interface with other work including utilities and electrical work, and that such establishment is the exclusive responsibility of the Contractor.

B. Arrange mechanical work in a neat, well organized manner with piping and similar services running parallel with primary lines of the building construction, and with a minimum of 7'0" overhead clearance where possible.

C. Locate operating and control equipment properly to provide easy access, and arrange entire mechanical work with adequate access for operation and maintenance.

D. Give right-of-way to piping which must slope for drainage.

E. Advise other trades of openings required in their work for the subsequent move-in of large units of mechanical work (equipment).

F. Coordination Drawings: For locations where several elements of mechanical (or combined mechanical and electrical) work must be sequenced and positioned with precision in order to fit into the available space, prepare coordination drawings (shop drawings) showing the actual physical dimensions (at accurate scale) required for the installation. Prepare and submit coordination drawings prior to purchase, fabrication, or installation of any of the elements involved in the coordination. Coordination drawings at 1/4-inch scale will be required for all mechanical rooms.

G. Work for Other Trades: Refer to, read and study, all of the General and Technical specification sections in all Divisions for this project and provide all work required of the Division 23 trades which may be required therein or thereby including, but not by way of limitation, connection of utilities to equipment provided under other Divisions, providing and/or installing ducts, louvers and fans in connection with equipment provided under other Divisions (eg: kitchen exhaust hoods, emergency generator radiators, etc.), providing gas vents for equipment provided under other Divisions, etc.

H. Coordinate ductwork and fire damper installation with Architectural Drawings and Specifications indicating and/or describing fire rated construction and provide properly rated fire dampers in all penetrations of duct and duct devices through fire rated construction. In some cases fire dampers are indicated on the Drawings, in other instances they are not. It is fully the responsibility of the Contractor to coordinate the requirements of fire rated construction as indicated and/or specified and provide fire dampers in ducts where required whether indicated on the duct drawings or not.

I. Phasing Plan: Provide a complete phasing plan, consisting of drawings with descriptions of the work for each project phase, coordinated with all other work in this project. The plan shall include all plumbing, HVAC, control, equipment part load, etc. requirements needed to keep the existing facility in operation until the first phase work is completed and operational, then, keeping the first phase of work operational while the balance of the work is accomplished.

1.7 MECHANICAL PLANS

A. The mechanical plans are intended to be diagrammatic based on one manufacturer's equipment. The plans are not intended to show every item in its exact location, the exact dimensions, or all the details of the equipment. Verify the exact dimensions of the equipment proposed.

B. Installation shall be within the limitations imposed by the architectural, structural, electrical and plumbing, and fire protection (sprinkler) requirements with adequate space for maintenance.

1.8 QUALITY ASSURANCE, STANDARDS, AND SYMBOLS

A. Contractor for this DIVISION must have installed at least three (3) similar type and size jobs and mechanical contracting shall be their primary business.

B. Qualifications of Subcontractors: Must be properly licensed and established as a General Contractor and as an HVAC Contractor and as a Master Plumber at location of the work and shall maintain locally adequate

service facilities. They shall have had previous experience in the satisfactory installation of at least three systems of this type and size.

C. General: Refer to the technical sections for general administrative/procedural requirements related to compliance with codes and standards. Specifically, for the mechanical work (in addition to standards specified in individual work sections), the following standards are imposed, as applicable to the work in each instance:

1. AWS standards for welding.

D. All work shall be in accordance with the latest editions adopted of following codes and regulations:

1. National Fire Protection Agency
2. Occupational Safety and Health Administration
3. International Code Council, Inc. Codes
4. State Building Code
5. Local Building Codes

E. Where any of the above are at variance with the drawings and specifications, the requirements of the above codes and regulations shall take precedence and the costs necessary to meet these shall be in included in the bid price.

F. The contractor is solely responsible for meeting all OSHA regulations and insuring job site safety.

G. Symbols: Except as otherwise indicated, refer to the "ASHRAE Handbook of Fundamentals" for definitions of symbols used on the drawings to show mechanical work.

1.9 QUESTIONS AND CLARIFICATIONS OF BID DOCUMENTS

A. Bidders shall not rely on any verbal clarification of the drawings or specifications. Any questions or clarifications shall be referred to the Architect/Engineer at least five (5) working days prior to bidding to allow for issuance of an addendum. After the five (5) day deadline, the bidder shall make his own decision and qualify his bid if he feels it necessary.

1.10 TEN (10) DAY PRIOR APPROVAL

A. This requirement for prior approval is independent of others called for in other Divisions of these specifications.

B. Any fixture, equipment , material, or components of fixtures and equipment proposed to be furnished for this project, other than manufacturer's equipment actually named in the bid documents, shall have pertinent submittal data with descriptive cover sheet submitted to the Architect with a copy to the Engineer. The request for prior approval shall include 1) the project bid date, 2) the specification section number referenced, 3) the paragraph referenced within that section, and 4) the manufacturer’s name being requested for prior approval. This data shall be received by the Engineer ten (10) days and one hour prior to bid opening data for inclusion in an addendum if and when reviewed and accepted for bidding.

C. This is for pre-bid review and is not to be regarded as submittals required for construction. It is understood that approval shall be for the manufacturer to quote the project during bidding, subject to the requirements of the contract documents.

D. Bidder shall base his bid on items of equipment actually named in the bid documents or addendums issued prior to biddings. Verbal acceptance will not be accepted unless verified in writing. It is the bidders' responsibility to ascertain that all equipment has been accepted by requiring copies of the written acceptance.

1.11 GUARANTEES

A. All equipment, materials and workmanship shall be guaranteed in writing for a period of one (1) year beginning with the date of acceptance. Special warranties will be called for under some sections of equipment. This warranty shall be in writing and shall include written copies of the factory warranties with expiration dates on items of equipment where the warranty date may differ from the acceptance date. No warranty shall start before the acceptance date.

B. The contractor's warranty shall include at least two (2) inspections of the system to repair and/or replace any items found defective during this warranty period.

C. After completion of the work, the Contractor shall operate the equipment he installs for a period of five (5) days, after which time it shall be considered as a test of satisfactory operation. During this time, he shall instruct the owner's operating personnel in the correct operation of the equipment.

D. Contractor shall provide the owner with two (2) sets of manufacturer's operating and maintenance manuals and parts list for all equipment and materials furnished by him. In addition to the manufacturer's data, contractor shall provide a maintenance schedule listing routine maintenance operations and the frequency thereof.

1.12 SUBMITTALS:

A. General: The Drawings and Specifications may make mention to specific Manufacturer's model numbers. It is understood that these model numbers direct the Contractor to a "Type" or "Series", and are not intended to indicate all suffix designations, prefix designations, or variations of types and models. The type, series, or variation of the model number given must be determined by including all specified items, performance, etc. specified, indicated, and/or detailed. Refer to the Division 1 sections for general requirements concerning work-related submittals (refer to other Divisions I sections for administrative submittals).

B. SUBMITTALS

1. Thirty days subsequent to either the signing of the General Contract or from the Notice to Proceed, or from the Letter of Intent, the long lead item submittals shall be in the offices of the Prime Design Professional. All other materials and equipment not submitted within the above mentioned time shall be provided as specified in the contract documents without substitutions.
2. Prior to starting any construction, submit schedule of items proposed for this work with approved substitutions to specified items clearly noted as such on the summary page. Submit all items, equipment, materials, etc. at the same time, with descriptive cover and table of contents. Submittal shall include a summary page listing all items contained therein. Submittal shall include illustrations,

drawings and engineering data for review by the Engineer. **Submit in time to allow not less than ten (10) working days** for checking and transmittal without delaying the construction schedule. Submit all items at one time and not less than thirty (30) days after the award of the contract. Submittals shall be clearly designated as to the intended item with identification as to unit number or other marking to show location, service and function.

3. Submittals shall be submitted all at one time. Partial submittals will not be accepted. Any item not submitted shall be provided as specified or indicated. Subsequent submittals for additional specific items shall not be accepted.
4. The submittal shall be in Adobe PDF format with each individual specification section bookmarked to allow for easy access to specific items. Specification sections to have nested bookmarks for each item/major piece of equipment covered by that specification.
5. The Contractor, by submitting, certifies that those submitted items, materials, equipment, etc., are those that, if not “rejected” or “returned for correction”, shall actually be installed, without exception, addition or substitution, as work of the project.
6. By submitting the required submittals, the Contractor certifies that the Electrical Installer has reviewed all electric power using equipment has been reviewed by the Electrical Installer and that any and/or all power circuits have been coordinated and that all power circuits shall match the equipment provided, whether properly indicated on the Electrical Drawings or not. See also Paragraph 2.4.
7. Any equipment installed without prior (review) acceptance shall be subject to rejection and replacement unless such items were identified by name on the bid documents.
8. The supplier, by submitting, certifies that the materials or equipment proposed is satisfactory for the application intended and that the materials and equipment are in current production with no anticipated plans to cease production.
9. Contractor agrees that submittals processed by the Engineer are not change orders; that the purpose of submittals by the contractor is to demonstrate to the Engineer that the contractor understands the design and specification concept, and that he demonstrates this understanding by indicating which equipment and materials he intends to furnish and install with the fabrication and installation methods he intends to use.
10. Contractor further agrees that if deviations, discrepancies or conflicts between submittals and contract documents are discovered either prior to or after submittals are processed by the Engineer, the contract documents shall control and shall be followed.
11. Submittals shall include:

    a. 1/4 scale shop drawings of equipment.
    b. Power and fuel consumption, voltage and ampere rating.
    c. Capacity and conditions at which rated.
    d. 1/8 scale shop drawings of duct systems; piping systems; drain, waste, vent systems, domestic water systems
    e. Volts, phase and full load amps of each electrical item

12. When major items of equipment or systems are submitted as substitution for that which is called for by the contract documents, and significantly different dimensions or concepts are encountered in such proposal, the submittals shall include 1/4" scale drawings of proposed equipment and system layout with sections. These drawings shall indicate all spacial relationships between equipment, piping, duct, electrical work, building and space constraints, etc.

1.13 CONFLICTS

A. Where any conflict between the requirements of these specifications and the requirements of the associated drawings occur, the more stringent requirements shall govern unless approval is obtained through the Engineer. All such conflicts shall be brought to the Engineer's attention.

B. Where technical specifications include installation instructions, in their “Part 3 – Execution” paragraph, for materials, items, equipment, etc. which are not mentioned in their “Part 2 – Products” paragraph, it shall be considered as an editing inaccuracy and shall not be construed as Part 3 allowing the use of products not mentioned in Part 2.

1.14 COORDINATION DRAWINGS

A. Prepare coordination drawings which fully coordinate the location and interface requirements (due to special limitations and constraints) of the work including Architectural, Structural, Fire Suppression (Protection), Plumbing, HVAC, Electrical, Owner furnished equipment, etc. to eliminate construction conflicts. This requirement is fully the responsibility of the Contractor and these drawings shall not be submitted for review but shall be maintained at the jobsite and updated as necessary to prevent conflicts. The designers shall assume, as a result of receiving and reviewing other required submittals, that this coordination has be accomplished, that these drawings have been made and kept up to date, and no other consideration shall be given for construction interferences which may arise

1.15 TEMPORARY FACILITIES

A. General: Refer to other Divisional sections for general requirements on temporary facilities. The following facilities (source, distribution, utilization, operation, maintenance and removal) are hereby defined to be mechanical work (work of this section), and including alternative temporary use of permanent facilities (if any):

1. Temporary use of mechanical work of this Contract.
2. Temporary water, but excluding drinking water not connected to a piping system.
3. Piped drainage.
4. Gas service connected to utility company service.
5. Temporary steam/hot water heating.
6. Piped sanitary facilities, but excluding temporary use of Owner's existing facilities (if any).
7. Piped fire protection facilities, including hoses (if any).

PART 2 - PRODUCTS

2.1 GENERAL

A. All products shall be new, of first line quality of grade and type shown on the drawings and specified, or equals accepted by the Architect/Engineer in writing.

B. All products shall be in current production with no notice having been given that such product is to be drastically changed, modified, or discontinued from production.

C. The supplier, by submitting, certifies that equipment being processed is proper for the application intended and that it has the capacity specified.

D. Lead-Free Requirements:

1. Any product designed for dispensing potable water must meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. This requirement supersedes specific model numbers stated either in these specifications or on the drawings, should a non lead-free model number be used for products designed for dispensing potable water.

2.2 COMPLETE SYSTEM

A. All products, materials and accessories shall be furnished and installed as required for a complete system ready for Owner's beneficial use.

2.3 PRODUCTS, MECHANICAL WORK

A. General: Refer to Division 1 sections for general requirements on products, materials and equipment. The following provisions expand or modify the requirements as applicable to mechanical work:

1. Product Listing: Prepare the product listing for mechanical work, separately from the listing(s) of products for other work. Include listing of each significant item of equipment and material used in the work; and indicate the generic name, product name, manufacturer, model number, related specification section number(s), and estimated date for each start of installation. Bulk materials, including pipe and sheet metal, taken from Fabricator's/Installer's stock need not be listed.
2. For principal equipment item, list the power and fuel consumption ratings, and the primary ratings.

B. Submit list within 30 days of Contract Date.

C. Compatibility: Provide products which are compatible with other products of the mechanical work, and with other work requiring interface with the mechanical work. Provide products with the proper or correct power characteristics, fuel-burning characteristics and similar adaption’s for the project. Coordinate the selections from among options (if any) for compatibility of products.

D. Equipment and Material Deviations: When any material or piece of equipment is specified on the plans or in the specification by reference to one manufacturer's name or model number, it is intended to establish the required standard of design and quality, and it is understood that the phrase "or approved equal" is hereby inserted following the one manufacturer's name, whether such phrase occurs or not.

E. When the drawings and/or specifications indicate one or two manufacturer's names for materials and equipment, the bidder may submit his bid based on material or equipment of manufacturers not named but considered by the bidder to be equal to the standard of quality and design specified. However, such substitutions must be accepted by the Architect/Engineer as equal. If the bidder elects to bid on a substitution without obtaining the written consent of the Architect/Engineer prior to receipt of bids, then it will be understood that proof of compliance with specified requirements is the direct responsibility of the bidder and no such materials and/or equipment may be purchased or installed without written acceptance of the Architect.

F. Bidders are advised to ascertain such acceptance from their suppliers by requesting copies of the acceptance in writing, signed by the Architect or Engineer. Bidders are also advised to submit a stamped, self-addressed envelope when requesting said copies.

2.4 ELECTRICAL PROVISIONS OF MECHANICAL WORK

A. All electrical work required in association with the HVAC work (in order to provide complete operating systems of Fire Suppression, Plumbing, HVAC and HVAC controls) shall generally be a part of the Division 26 work. However, there are certain portions of the electrical requirements which shall be a responsibility of the Division 23 work, which shall be executed in accordance with applicable Division 26 Specification requirements. The electrical provisions of mechanical work, where it may be furnished integrally with mechanical work, can be summarized (but not by way of limitation) to include the following: 1) Motors, 2) Motor starters, 3) Wiring from mechanical equipment to electrical work termination (junction box or disconnect switch), 4) Control switch, pilot lights, interlocks, control transformers and similar devices, 5) Variable Frequency/Variable Speed Drives with Isolation Transformers where so required, 6) Electrical heating coils and similar elements in mechanical equipment, 7) Electrical work specified as mechanical work in the HVAC control system, 8) Drip pans to protect electrical work, and 9) Work specified elsewhere and/or in other sections as part of the Mechanical Work Requirements.

B. Responsibility: It is the sole responsibility of the Contractor to coordinate the electrical requirements of each item of equipment provided with the electrical circuits required and to insure their compatibility and compliance with the N.E.C.

C. For the purposes of these Specifications, the term “single point power connection” (SPPC) shall mean explicitly that. A single point power connection shall require no other circuits to complete the system. If an item of equipment is provided which is scheduled and/or specified for SPPC but requires additional circuits, the Contractor shall be responsible for the additional circuits, transformers, circuit protection, sub-fusing, etc. in accordance with the NEC and/or the Division 26 specifications for this project.

D. If such an instance occurs where an item of equipment, heat trace, control element, etc., is shown or required, and no electrical provisions are elsewhere specified, shown or indicated, the Contractor shall provide a properly sized and protected power circuit for it (them) as part of the Division 23 work in accordance with the Division 26 sections of these specifications and the N.E.C.

E. If such an instance occurs where the electrical characteristics of an item of equipment indicated in/on Mechanical Drawings do not match those indicated in/on the Electrical Drawings, it shall be considered as a drafting inconsistency and the Contractor shall be required to provide equipment which is properly matched to the circuits and circuit protection provided.

F. Where mechanical devices are to be incorporated into fabricated electrical units at the factory, furnish devices to the designated factory well in advance of time that the units are needed at the project.

G. Where control transformers are provided, insure that they are compatible with the electrical circuits provided (example: if a 480volt/3phase/60 hz, 3-wire power circuit serves a mechanical item of equipment, provide 480 volt to low voltage transformer(s) for controls, if low voltage controls so require, not 277 volt transformers).

H. Standards: Where not otherwise indicated, comply with applicable provisions of the National Electrical Code, NEMA standards, and sections of Division 26 of these specifications. All wiring, including controls, shall be installed in conduit with wire sizes according to NFPA 70 unless otherwise indicated on the plans.

I. Motors:

1. Manufacturer: Allis-Chalmers, Century/Gould, General Electric, Louis Allis, Marathon, Reliance or Westinghouse. Where selection of motor manufacturer is within Contractor's control (independent of mechanical equipment selection), provide motors produced by a single manufacturer to the greatest extent possible.
2. Temperature Rating Class B insulation, or Class F when used with variable Frequency (Variable Speed) Drive(s), or as otherwise indicated or required for service indicated.
3. Starting Capability: As required for service indicated, but not less than 5 starts per hour.
4. Phases and Current: Refer to project drawings.
5. Service Factor: 1.15 for polyphase; 1.35 for single-phase.
6. Direct drive motors served by variable speed drives: Provide shaft grounding rings.
7. Construction: General purpose, continuous duty; Design "B", except "C" for high starting torque applications.
8. Frames: NEMA No. 48, except 56 for heavy-duty applications.
9. Bearings: Ball or roller designed for thrust where applicable; shaft seals and regreasable, except provide permanently sealed where not accessible for greasing. Sleeve-type bearings permitted only where indicated for light-duty fractional hp motors.
10. Enclosure Type: Open drip-proof for normal concealed indoor use, guarded where exposed to employees or occupants. Type II for outdoor use, except weather-protected Type I where adequately housed. Totally Enclosed Fan Cooled (TEFC) motors shall include a rain cap if required for protection when mounted in a vertical configuration.
11. Overload Protection: Built-in thermal; with internal sensing device for stopping motor, and for signaling where indicated.
12. Noise Rating: "Quiet", except where otherwise indicated. Motors used with variable frequency/speed drives shall be selected such that neither the motor nor the drive whines or makes any objectionable noise.
13. All electric motors shall operate at a maximum of 1750 rpm and have open drip proof enclosures for dry indoor applications and totally enclosed fan cooled or air over motors for outdoor applications. Motors located on air handling units shall be mounted in rubber supports or the fan shall be independently supported on spring isolators. Motors located in the conditioned space shall be selected for quiet operation and shall not produce objectionable "motor noise" in the space.

14. Electrical characteristics shall be verified from the Electrical drawings, prior to bidding, and verified on the job by the Electrical Contractor (prior to ordering by the Electrical Installer).

J. Starters/Switches:

1. Manufacturer: Allen-Bradley, Cerus, Furnas, Cutler-Hammer, General Electric, or Westinghouse.
2. Motor starters shall be sized in accordance with the National Electrical Code and proper heater elements shall be provided and installed. Match AIC Rating of Electrical Panels serving the motor starter, 30K AIC minimum.
3. Starter Characteristics: Type I general purpose enclosure with padlock ears and supports for mounting as indicated. Starter type and size as recommended by motor manufacturer. Locate disconnect switch within sight of motor.

4. Manual Switches: Provide on motors 1/3 hp and smaller, except where automatic control or interlock is indicated; include pilot light. Provide overload protection where not protected by panelboard circuit breaker or fused disconnect switch.
5. Magnetic Starters: Provide for 1/2 hp and larger motors, and for smaller motors on automatic control or with interlock switch.
6. Starters shall consist of a horsepower rated magnetic contactor with a minimum of 1NO and 1NC auxiliary contacts and solid state electronic overload relay. Overload relay shall protect all three phases with a wide range current setting and trip class to allow field adjustment for specific motor FLA. Interchangeable heater elements are not acceptable. Overload relay shall provide phase failure, phase loss, locked rotor and stall protection.
7. Provide a manual reset pushbutton on the starter cover to restore normal operation after a trip or fault condition.
8. Each starter shall include an installed 50VA control power transformer (CPT) with protected secondary. The CPT must accept the available line voltage and the control voltage shall not exceed 120V.
9. Installed accessories shall include Hand-Off-Auto operation switch with 22mm style operator interfaces. Include LED pilot light indicators for Hand, Off, Auto, Run and Overload conditions. All pilot devices shall be water tight and dust tight.
10. When remotely controlled by an automation system, the starter shall include remote run terminals which accept both a voltage input signal and a contact closure. The voltage run input shall accept both AC and DC signals including 24VAC, 120VAC, 24VDC and 48VDC to allow direct connection of the transistorized automation signal to the starter.
11. In applications where the motor is interlocked with a damper or valve, the actuator control must reside within the starter enclosure. The starter must provide a voltage output to operate the actuator to open the damper or valve without closing the motor circuit. The starter will only close the motor circuit and start the motor after it has received a contact closure from a limit or end switch confirming the damper or valve position.
12. The starter shall provide a provision for Fireman's Override operation. When activated, the starter run the motor in any mode (Hand, Off or Auto) regardless of other inputs or lack of inputs either manual or auto. The purpose of the Fireman's Override input is to act as a smoke purge function. Fireman's Override has priority over the Emergency Shutdown input.
13. If the starter is controlled by a fire alarm or life safety system, the starter shall include an Emergency Shutdown input which will disable the starter from operating in either Hand or Auto mode regardless of other inputs either manual or auto.
14. Boiler Rooms: Provide manually operated remote emergency shut-down switches, fully in accordance with ASME CDS-1-2009, for all boilers, and for all water heaters in excess of 200,000 btu (58 kw) fuel or power input or over 120 gallon water storage. Switches shall be located on the outside of the boiler room next to the room door, or just inside of the room door for rooms having doors opening to the building exterior.Switch to be equal to Eaton 10250T5B62-S106, NEMA 4, 2 NC contacts

K. Variable Frequency/Speed Drives: Refer to specification section 230522.

L. Wiring/Connections:

1. Motors: Wire connections in flexible conduit, except where plug-in electrical cords are indicated and permitted by governing regulations.

2. General Wiring: Comply with applicable provisions of Division 26 sections.

3. Control wiring: This contractor is responsible for all line voltage control wiring required for interlocked valves, dampers and other control devices. Controls subcontractor is responsible for any and all low voltage control cable/wiring required for a complete and operational lsystem. In general, Division 26 contracto rwill provide a single 120-volt circuit to the control panel.

M. Drip Pans:

1. Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical or electronic work which is sensitive to moisture; otherwise provide drip pans under mechanical piping, sufficient to protect electrical work from drips. Locate pan immediately below piping, and extend a minimum of 6" on each side of piping and lengthwise 18" beyond equipment being protected. Fabricate fans 2" deep, or reinforced sheet metal with rolled edged and soldered or welded seams; 20 gage copper, or 16 gauge steel with 2 oz. zinc finish hot dripped after fabrication. Provide ¾" copper draining piping, properly discharged.

2.5 UNDERGROUND STRUCTURES AND FACILITIES

A. All underground structures and facilities for Division 23 work including, but not by way of limitation, Fire Suppression/Fire Protection, Plumbing and HVAC, shall be DOT rated for H20 loading

PART 3 - EXECUTION

3.1 WORKMANSHIP

A. All work shall be performed by competent mechanics using proper tools and equipment to produce first quality work. All work shall be neatly installed, accessible for maintenance and complete with all accessories required.

3.2 CEILING RETURN AIR PLENUMS

A. In instances where the cavity spaces above ceilings are used as return air plenums, the contractor shall insure that adequate return air path(s) above the ceiling(s) are provided (whether shown or indicated or not) from each occupied room or space into the ceiling cavity and then from the ceiling cavity above each room or space back to the appropriate air handling/blower coil unit(s).

B. Providing return air paths as required by this paragraph may require providing openings (which are not shown or indicated) in walls which extend above the ceiling(s) and are tight to the structure above.

C. Providing return air paths as required by this paragraph may also require providing ceiling mounted return air grilles (which are not shown or indicated) where return air type light fixtures are either not present or not present in large enough numbers to provide an adequate return air path.

D. Return air paths provided through fire rated walls above ceilings shall be provided with appropriately rated and/or classified fire dampers.

E. All materials and equipment installed in HVAC return air plenums shall have a 25/50 flame spread/smoke developed index maximum when tested in accordance with ASTM E 84.

3.3 ACCESSIBLE PROVISIONS

A. The Contractor shall comply with all provisions of the “Americans with Disabilities Act” (ADA), whether indicated or specified elsewhere or not.

B. Thermostats shall be mounted at 54” above the floor where side reach is possible and at 48” where only forward reach as possible.

3.4 ACCESS

A. Access Units: The work of this article is limited to the provisions for access through other work for access to mechanical work, and does not include internal access provisions (within the mechanical work). In general and where possible, furnish or furnish-and-mount required access units in other trades' work prior to their work, so that cutting and patching for the subsequent installation of such access units will not be required. In occupied spaces, provide finished access units of the maximum concealment type, including locks where appropriate, and matching access units provided in the same expanse of finish (for non-mechanical access, if any). Access units shall meet the fire and/or smoke rating of the construction in which installed.

B. Scope: The scope of access units to be furnished or provided as indicated on mechanical drawings or specified in Division 23 sections, and those additional units required for adequate access to mechanical work and not shown or specified individually.

C. Access Doors: Standard welded-steel construction, 16 gauge frames and 14 gauge door panels, 175^{o} concealed spring hinges, rust-inhibitive prime coat, flush cam lock (for screw-driver operation where keyed lock is not required), recessed to receive applied finish where applicable, 5-pin/disk tumbler lock where indicated.

D. Floor Doors: Welded steel plate/angle construction for 300 lb/sf loading, brass/bronze hinges with stainless steel pins, screw-driver or wrench operated latch with inside handle where applicable, rust-inhibitive prime coat. Where indicated as "sealed", provide waterproof and airtight neoprene gasketed construction. Provide recessed-finish construction where indicated to receive in-set floor finish.

E. Removable Access Plates: Where only hand access is sufficient, provide removable plate-type access unit, of minimum size which will facilitate the required access. Provide units of the type, style, design, material and finish appropriate for the location and exposure in each instance. In exposed surfaces of occupied spaces, provide round plate units, flush floor units and frameless low-profile wall units, primed-for-paint in painted surfaces and polished chrome or stainless steel finish in other surfaces.

3.5 CUTTING AND PATCHING

A. Cutting and Patching Requirements: Comply with the requirements of other Divisions for the cutting and patching of other work to accommodate the installation of mechanical work. Except as individually authorized by the Architect/Engineer, cutting-and-patching of mechanical work to accommodate the

installation of other work is not permitted, other than necessary penetrations of mechanical sheet metal work for electrical conduit and similar purposes.

3.6 WORK BY OTHER TRADES

A. Cutting, patching, furring or painting shall be done by the affected trade at this contractor's expense for changes required in the finish work.

B. Openings in walls, floors and roof to be furnished by the General Contractor. This contractor shall furnish the General Contractor with the location and size required. This contractor shall furnish all sleeves, frames including framing between joist (unless shown on the Structural plans), access doors, prefabricated curbs, roof flashing, counter flashing and other accessories necessary for a complete installation. Only those items specifically shown and/or specified in other sections are excluded.

C. Power wiring, including final connections, is by the Electrical Contractor (However, this contractor is in some cases made responsible for power wiring by these specifications. It is in these cases that this contractor must arrange for and bear the cost of power wiring such as that associated with equipment auxiliaries, power for control circuits, etc.) This contractor shall install all motors and furnish all starting equipment to the Electrical Contractor for installation. Control wiring, including conduit, switches, thermostats, interlocks, etc., shall be furnished by this contractor unless specifically shown on the Electrical drawings. This contractor shall see that the electrical components mounted on the equipment do not block access to service areas of the equipment (such as disconnects switches mounted on the equipment).

D. Power and fuel for testing shall be by the General Contractor.

E. Door grilles shall be furnished by this contractor and installed by the General Contractor.

F. Floor drains and hub drains shall be the responsibility of the Plumbing Contractor. This contractor shall connect drains from his equipment to these drains with an open site drain connection or air gap. This contractor shall review the drain locations and insure that mechanical equipment will not interfere with drain location. If a conflict is noted, notify the Architect and coordinate drain location.

3.7 FOUNDATIONS AND SPECIAL SUPPORTS

A. Furnish and install all special foundations and supports required for equipment installed under this Section, unless they are a part of the building structure and are shown in other sections.

B. All floor mounted shall be mounted on housekeeping pads which have are a minimum 6" higher than surrounding floor, grade, or surface and which are 6" larger in each plan dimension that the equipment installed thereon.

3.8 EXCAVATING FOR MECHANICAL WORK

A. General: The work of this article is defined to include whatever excavating and backfilling is necessary to install the mechanical work. Coordinate the work with other excavating and backfilling in the same area, including dewatering, flood protection provision, and other temporary facilities. Coordinate the work with other work in the same area, including other underground services (existing and new), landscape

development, paving, and floor slabs on grade. Coordinate with weather conditions and provide temporary facilities needed for protection and proper performances of excavating and backfilling.

B. General Standards: Except as otherwise indicated, comply with the applicable provisions of the Division 2 sections for mechanical-work excavating and backfilling. Refer instances of uncertain applicability to the Architect/Engineer for resolution before proceeding.

C. Piping Support: Support pipe 5" and smaller directly on undistributed soil. Support pipe 6" and larger, and tanks/vessels, on compacted and shaped sub base material of depth shown but not less than 6" deep. Compact previously disturbed and unsatisfactory subsoil to provide adequate, uniform support for mechanical work; or excavate and replace with stable sub base material or lean concrete.

D. Water-Bearing Pipe: Except as otherwise specifically indicated, place exterior underground water-bearing pipe (including drainage lines) a minimum of 3'-6" below grade (measured to top of pipe).

E. Roadways: Where piping is less than 2'-6" below surface of roadway, provide encasement in Class 2500 concrete, 4" minimum coverage all around.

F. Sequencing: Delay backfill and encasement of piping until testing of piping system has been completed.

G. Backfill first two feet minimum of piping trench (but no less than 6” cover over piping) with backfill class concrete. Backfill balance with clean dirt or sand, no rocks, clods or trash with a minimum of 8” of clean top soil at grade. Take care not to disturb the pipe grade or alignment. Compact around and under the pipe carefully. Finish all backfill with approved material and leave slightly mounded. Clean up around the ditch area to remove trash and any excess dirt.

H. Replacement of Other Work: Where it is necessary to remove and replace landscape work, pavement, flooring and similar exposed finish work, engage the original installer to install the replacement work; except where the work existed prior to the work of this Contract, engage only experienced and expert firms and trades persons to replace the work.

3.9 CONCRETE FOR MECHANICAL WORK

A. General: The work of this article is defined to include whatever concrete work is necessary or shown specifically for installation of the mechanical work. Coordinate the work with other work, particularly other concrete work and accessories.

B. General Standards: Except as otherwise indicated, comply with applicable provision of Division 3 Sections for mechanical-work concrete, including formwork, reinforcement, mix design, material (use mix designs and materials accepted for Division-3 work where possible), admixtures, accessories (including waterstops), placing of wet concrete, finishing, curing, protecting, testing, submittals, and other requirements of the concrete work. Refer instances of uncertain applicability to the Architect/Engineer for resolution before proceeding.

C. Associated Work: Where expansion joint fillers and sealants are required, provide the types indicated and comply with applicable provisions of the other sections. Where a moisture or vapor barrier is indicated, under or behind concrete work, provide fiber-reinforced, plastic-core, asphalt-saturated felt-laminate sheets, 1/8" thick, 70 lbs. per 100 sq. ft., 0.005 perm rating.

D. Classes and Applications: Except as otherwise indicated, provide strength classes as follows, with the following cement content and water/cement ratios (for the indicated applications and similar required applications):

1. 4000 psi Class: 565 lbs. cement/yd. (6.0 sacks); 0.57 water/cement ratio. Provide 4000 Class for tanks, vaults, beam-type foundations and similar structures.
2. 3000 psi Class: 500 lbs. cement/yd. (5.25 sacks); 0.68 water/cement ratio. Provide 3000 Class for miscellaneous underground structural concrete, reinforced encasement, block-type foundations (with smallest dimension at least 0.2 x largest dimension), curbs, pads, inertia blocks (unframed type), and similar structural support work, and whenever otherwise unspecified or not indicated by class.
3. 2500 psi Class: 450 lbs. cement/yd. (4.75 sacks); 0.75 water/cement ratio. Provide 2500 Class for plain encasement, filling steel-framed units, and similar work.
4. Rough Grouting Class: 565 lbs. cement/yd (6.0 sacks); 0.75 water/cement ratio; adjust aggregate sizes to facilitate placement. Use for rough grouting, not for setting equipment bases.
5. Backfill Class (Lean Concrete): 375 lbs. cement/yd. (4.0 sacks); 0.87 water/cement ratio. Use for backfilling where piping is installed in trenches below grade.

3.10 PAINTING OF MECHANICAL WORK

A. General: The work of this article is defined to include general painting of mechanical work at the project site. Coordinate the painting with the painting of other work of a similar nature, and comply with indicated color and color matching requirements. Except as otherwise indicated, paint surfaces of mechanical work which would normally be painted in the application and exposure indicated.

B. General Standards: Except as otherwise indicated, comply with applicable provisions of other Sections for mechanical-work painting. Refer instances of uncertain applicability to the Architect/Engineer for resolution before proceeding.

C. Painting Requirements: Refer to the mechanical drawings for the extent of mechanical work of various categories (as designated for painting). The painting requirements can be summarized as follows, but not necessarily by way of limitation:

1. Work buried in soil or encased in concrete or insulation need not be painted (except for protective coatings specified with the piping system).
2. Painting of mechanical work exposed in occupied spaces of the building (not including machine rooms and maintenance/service spaces), and work exposed on the exterior (outdoors), is not specified as work of this section (not mechanical-work painting).

D. Paint the following categories of mechanical work which have not been fully factory-finished, except paint over factory finish which is not an acceptable color

1. Accessible ferrous metal (does not include stainless steel), regardless of whether exposed or to be concealed behind ceilings, shaft enclosures or similar finish construction; exclusive of cast iron which is either concealed or set flush with floors or decks.
2. Zinc-coated (galvanized) metal surfaces; but excluding surfaces which are concealed, except in "high humidity" areas.

3. Aluminum surfaces which have not been specifically anodized as a final finish, and excluding surfaces which are concealed.
4. Concrete, but only where adjacent non-mechanical-work concrete of a similar placement is required to be painted.
5. Insulation on piping, ductwork, equipment and similar work; but excluding concealed surfaces and aluminum-foil-faced insulation.

E. Paint inside of ductwork black, where it can be seen from occupied spaces through grilles or louvers (under any lighting condition).

F. Do not paint over name plates on equipment, sliding/rotating shaft surfaces, non-ferrous hardware/accessories/trim, and similar items where painting would normally be omitted.

3.11 NOISE AND VIBRATION

A. Install vibration isolators, flexible connectors, expansion joints and other safety measures to prevent noise and vibration from being transmitted to occupied areas. Equipment shall be selected to operate within the noise level recommended for the particular type installation in relation to its location.

B. After installation, make proper adjustments to eliminate excessive noise and vibration.

3.12 CONDENSATE DRAINS

A. Provide insulated type M copper condensate drain for all air handling units. Drains shall have a slope of not less than 1" in 40 feet and if possible, 1/4" per foot. Do not allow any sags or low points for water to collect. Provide trap of size equal to drain connection at unit and air gap at floor drain. Drain shall have a trap depth 1" greater than to the total fan static pressure, inches water column, or as detailed.

3.13 EQUIPMENT AND DUCTWORK CLEANLINESS DURING CONSTRUCTION

A. HVAC equipment and ductwork will be protected from dust and other pollutants during instillation and during initial equipment operation.

B. All air handling unit casings shall be hand-wiped clean prior to final test and balance.

C. Openings into installed ductwork and air-handling equipment not in active use will be sealed using taped plastic, taped cardboard, or other reasonably air-tight coverings. Ductwork delivered to job site will be protected prior to leaving fabrication shop. Sealing will occur prior to, or immediately upon installation of the ductwork or equipment. Regular inspections will be conducted by the Mechanical Contractor Superintendent to check for damaged or displaced coverings. Repair or replacement of damaged or displaced coverings will occur immediately upon discovery.

D. Construction work that generates air pollution will be avoided where ductwork or air handling equipment is being installed. If visible air pollutants are present in a space where ductwork is to be installed, spot cleaning or other measures will be used to prevent ductwork or equipment contamination.

E. Use of mechanical systems during construction:

1. Air handling Units will be protected with a temporary filter having a minimum rating of MERV 8 per ASHRAE 52.2-1999.
2. Distribution elements needing filters, including all return air ductwork, will be protected with temporary filters having a minimum rating of MERV 8 per ASHRAE 52.2-1999 unless otherwise noted. If used for prolonged periods, filters will be periodically inspected and replaced if dirty. All components of the distribution on the return side will be protected.

3.14 AUXILIARY DRAIN (SAFE) PANS

A. Provide 2" deep water proofed galvanized steel auxiliary drain pan (safe pan) under equipment concealed above ceilings or in attics. Pan to be drained (pipe size equal to equipment drain) to drip conspicuously into nearest plumbing fixture, on the floor or conspicuously on grade.

3.15 REVIEW BY ENGINEER

A. This contractor shall notify the Engineer seven (7) days prior to the beginning of the following stages of construction so that the Engineer may visit the site for review and consultation:

1. When ductwork installation begins.
2. When equipment installation begins
3. When major equipment is set and connected
4. When the system is to be charged
5. When piping is to be installed
6. Before ceiling installation begins.
7. When any lines or ducts are to be permanently concealed by construction
8. When control system testing begins
9. When Testing and Balancing begins

B. Should this contractor fail to notify the Engineer at the stages prescribed above, it shall then be their responsibility and cost to make ductwork accessible, expose any concealed lines or demonstrate acceptability of any part of the system. Any extra cost caused by the removed of other trades work shall be borne by this contractor.

3.16 EARLY START-UP

A. This contractor shall do all possible to see that the mechanical equipment is connected with electrical power as early as possible so that final balancing and testing can begin. Should this contractor be ready for operation and power is not available, the General Contractor and the Architect/Engineer shall be notified

3.17 CLEANING AND PATCHING

A. Thoroughly clean all equipment and remove all trash, cartons, etc...Make any necessary corrections or repair/replace any damaged materials or equipment. Leave the entire system in a thoroughly clean and orderly manner.

B. Any finished surfaces that have been scratched or discolored shall be touched-up or repainted to match the original color.

C. All metal items subject to rusting, inside or exposed to the weather, shall be given one coat of proper type rust preventive type primer as soon as installed. If final paint finish is not specified in other sections, then this contractor shall apply two (2) finish coats with color to be selected by the Architect.

3.18 MECHANICAL WORK CLOSE-OUT

A. General: Refer to the Division l sections for general closeout requirements. Maintain a daily log of operational data on mechanical equipment and systems through the closeout period.

B. Record Drawings: Provide mylar reproducible record drawings of the Mechanical work, give special attention to the complete and accurate recording of underground piping and ductwork, other concealed and non-accessible work, branching arrangement and valve location for piping systems, locations of dampers and coils in duct systems, locations of control system sensors and other control devices, and work of change orders where not shown accurately by contract documents.

C. Closeout Equipment/Systems Operation: Sequence operations properly so that work of project will not be damaged or endangered. Coordinate with seasonal requirements. Operate each item of equipment and each system in a test run of appropriate duration (with the Architect/Engineer present, and with the Owner's operating personnel present), to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance. Clean and lubricate each system, and replace dirty filters, excessively worn parts and similar expendable items of the work.

D. Operating Instructions: Conduct a full-day walk-through instruction seminar for the Owner's personnel to be involved in the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety, efficiency and similar features of the systems. This seminar to be scheduled ten days in advance. The entire seminar shall be recorded in standard format video cassette. Provide cassette with close-out documents.

E. Turn-over of Operation: At the time of substantial completion, turn over the prime responsibility for operation of the mechanical equipment and systems to the Owner’s operating personnel. However, until the time of final acceptance, provide one full-time operating technician who is completely familiar with the work, to consult with and continue training the Owner’s personnel.

F. Provide maintenance manual to consist of:

1. Table of Contents
2. Letter of Guarantee on Letterhead
3. For each major item of equipment
4. Operating instructions
5. Maintenance instructions
6. Parts lists
7. Equipment performance
8. Control diagrams with parts lists.
9. Operating Instructions

G. Bound manual shall be used during training of the Owner's personnel (manual must be submitted to Engineer and approved prior to such training).

END OF SECTION 23 0000

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

G. Insulation: Class F.

H. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Shaft Grounding Rings.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230519

METERS AND GAGES FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages (liquid filled only).
4. Pressure gage manifold
5. Gage attachments.
6. Test plugs.
7. Test-plug kits.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product Certificates: For each type of meter and gage, from manufacturer.

C. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Miljoco Corporation.
b. Palmer Wahl Instrumentation Group.
c. Weiss Instruments, Inc.
d. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue [or red] organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.
   a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. Flo Fab Inc.
   e. Miljoco Corporation.
   f. Trerice, H. O. Co.
   g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   h. Weiss Instruments, Inc.

2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of] [Grade C, plus or minus 3 percent of middle half of scale range.

B. Pressure gage manifold for pumps: Four port hydronic trumpet valve, spring return brass construction push-button for each port, Flow Conditioning Corporation TVI-4 series or equal.

2.4 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flow Design, Inc.
2. Miljoco Corporation.
3. Peterson Equipment Co., Inc.
4. Sisco Manufacturing Company, Inc.
5. Trerice, H. O. Co.
6. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
7. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.6 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flow Design, Inc.
2. Miljoco Corporation.
3. Peterson Equipment Co., Inc.
4. Sisco Manufacturing Company, Inc.
5. Trerice, H. O. Co.
6. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
7. Weiss Instruments, Inc.

B. Furnish two test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install valve and snubber in piping for each pressure gage for fluids (except steam).

J. Install test plugs in piping tees.

K. Install flow indicators in piping systems in accessible positions for easy viewing.

L. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

M. Install permanent indicators on walls or brackets in accessible and readable positions.

N. Install connection fittings in accessible locations for attachment to portable indicators.

O. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

P. Install thermometers in the following locations:
1. Inlet and outlet of each hydronic boiler.

Q. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each hydronic boiler.

R. Install Pressure gage manifold at each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

B. Scale Range for Cooling, Chilled-water Piping: 0 to 120 deg F.

C. Scale Range for Domestic Hot-Water Piping: 30 to 180 deg F.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range: 0 to 100 psi.

END OF SECTION 230519

SECTION 230523.12

BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.18 for solder-joint connections.
4. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

D. Refer to HVAC valve schedule articles for applications of valves.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:
1. Handlever:

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions or as required for insulation thickness.
2. Extended operating handle of non-thermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Conbraco Industries, Inc.
b. Crane; Crane Energy Flow Solutions.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Watts; a Watts Water Technologies company.

2. Description:

a. Standard: MSS SP-110.

b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.
k. Extended stem

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Steel Piping, NPS 2 and Smaller: Threaded ends.
4. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

END OF SECTION 230523.12

SECTION 230523.13

BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Types:

1. Gear Actuator: For valves NPS 6 and larger.
2. Handlever: For valves NPS 5 and smaller.

G. Valves in Insulated Piping: With stem extensions to match insulation thickness, with extended necks.

2.2 IRON, RESILIENT SEATED BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Center Line; Crane Energy Flow Solutions.
b. Conbraco Industries, Inc.
c. DeZURIK.
d. Hammond Valve.
e. KITZ Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Norriseal

2. Description:

a. Standard: MSS SP-67, Type I.

b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One--piece 316 stainless steel. Provide extended stem for all insulated piping systems
g. Lever Actuator: 10-position dial
h. Disc: 316 Stainless steel.
i. Bearings: Aluminum bronze, with EPDM O-ring seal

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 230523.13

SECTION 230523.14

CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Iron, plate-type “silent” check valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Block check valves in either closed or open position.

B. Use the following precautions during storage:

   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts..

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
1. ASME B16.1 for flanges on iron valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B31.9 for building services piping valves.

C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

2.2 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided “Silent” Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. DeZurik (Basis).
b. Milwaukee Valve Company.
c. Mueller Steam Specialty.
d. NIBCO INC.
e. Spence Engineering Company, Inc.
f. Val-Matic Valve & Manufacturing Corp.
g. Watts; a Watts Water Technologies company.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. Body Material: ASTM A536 Ductile iron, flow area equal to or greater than flow area of the connected pipe. Provide factory applied exterior paint.
d. Style: Silent, Compact wafer.
e. Plug and seat: ASTM A276 T304 stainless steel, replaceable in the field
f. Spring: ASTM A276 T316 stainless steel
g. Seat: Buna-N.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:
   1. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 230523.14

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

1.5 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit; a part of Atkore International.
    b. B-line, an Eaton business.
    c. Thomas & Betts Corporation, A Member of the ABB Group.
    d. Unistrut; Part of Atkore International.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.

3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel (indoors) or stainless steel (outdoors).
7. Metallic Coating: Electroplated zinc (indoors) or Hot-dipped galvanized (outdoors).

2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
4. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
6. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

7. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
8. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
10. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
11. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
3. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230553

IDENTIFICATION FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels
3. Pipe labels
4. Stencils (for ductwork)

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Marking Services Inc.
3. Seton Identification Products.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 STENCILS

A. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
2. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, acrylic enamel. Paint may be in pressurized spray-can form.
4. Color: Fluorescent Green.

B. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, acrylic enamel. Paint may be in pressurized spray-can form.
4. Color: Fluorescent Green.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:
1. Chilled Water Piping: White letters on a safety-green background.
2. Heating Water Piping: Black letters on a safety-yellow background.
3. Domestic Cold Water Piping: White letters on a safety-green background.
4. Domestic Hot Water and Recirculation Piping: Black letters on a safety-yellow background
5. Natural Gas Piping: Black letters on a safety-yellow background.
6. Condensate Drain: White letters on Safety-blue background.
7. Sanitary Drain: White letters on Safety-blue background.
8. Storm Piping: White letters on Safety-blue background.

3.5 DUCT LABEL INSTALLATION

A. Stenciled Duct Label: Stenciled labels showing service, AHU served, and flow direction for all ductwork exposed in Mechanical Rooms.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 15 feet in each space where ducts are exposed.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

SECTION 230593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

    a. Constant-volume air systems.
    b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems
    c. Primary-Secondary hydronic systems.

3. Testing, Adjusting, and Balancing Equipment:

    a. Heat Exchangers
    b. Motors.
    c. Boilers.
    d. Condensing units.
    e. Heat-transfer coils.

4. Duct leakage tests.
5. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Certified TAB reports.

C. Sample report forms.

D. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC or NEBB.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.7 FIELD CONDITIONS

A. Partial Owner Occupancy: Project is to be completed in phases. Owner may occupy areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor

amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.

e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
d. Mark final settings.

e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gage heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.

2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.

9. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

    a. Measure total water flow.

        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

    b. Measure pump TDH as follows:

        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gage heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

    c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.

d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure, and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gage heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Adjust water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.16 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.17 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.18 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent, except as required to maintain building pressurization as designed.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.19 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.20 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.

b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.

l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.

c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.

e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.

k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

M. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.21 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner and commissioning authority.

B. Owner or Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.22 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713

DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply, return, and outdoor air.
2. Indoor, exposed supply, return, and outdoor air.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches square.
2. Sheet Jacket Materials: 12 inches square.
3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

F. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; Commercial Board.
b. Fibrex Insulations Inc.; FBX.
c. Johns Manville; 800 Series Spin-Glas.
d. Knauf Insulation; Insulation Board.
e. Manson Insulation Inc.; AK Board.
f. Owens Corning; Fiberglas 700 Series.

G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M.
b. Certainteed; SAINT-GOBAIN.
c. Thermal Ceramics.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
d. Mon-Eco Industries, Inc.; 22-25.

D. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
    b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
    b. Eagle Bridges - Marathon Industries; 570.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
    d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ABI, Ideal Tape Division; 428 AWF ASJ.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
   c. Compac Corporation; 104 and 105.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.

    a. Products: Subject to compliance with requirements, provide one of the following:

        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; CD.
        3) Midwest Fasteners, Inc.; CD.
        4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, provide one of the following:

        1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
        2) GEMCO; Perforated Base.
        3) Midwest Fasteners, Inc.; Spindle.

    b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    c. Spindle: Aluminum, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

    a. Products: Subject to compliance with requirements, provide one of the following:

        1) AGM Industries, Inc.; RC-150.
        2) GEMCO; R-150.
        3) Midwest Fasteners, Inc.; WA-150.
        4) Nelson Stud Welding; Speed Clips.

    b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.9 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

D. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive, insulation pins, and **fully apply mastic over all joints**.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Apply mastic according to manufacturer's recommended coverage rates per unit area.
4. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

6. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
7. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
8. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive, insulation pins, and **fully apply mastic over all joints**. Install corner angles on board insulation applications.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Apply mastic according to manufacturer's recommended coverage rates per unit area.
4. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

8. Install corner angles on board insulation applications.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
6. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Comply with manufacturer's written installation instructions.

B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

C. Insulate duct access panels and doors to achieve same fire rating as duct.

D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return.
4. Indoor, exposed return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE:

A. Concealed, round and flat-oval, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Concealed, rectangular, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

C. Rectangular, return-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

E. Exposed, rectangular, supply-air duct insulation shall be the following:
1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

F. Exposed, rectangular, return-air duct insulation shall be the following:
1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

G. Exposed, rectangular, outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

H. Exposed, return-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

I. Exposed, outdoor-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

END OF SECTION 230713

SECTION 230716

HVAC AND PLUMBING EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Chilled-water pumps.
2. Air separators.
3. Expansion tanks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For equipment applications, provide insulation without factory-applied jacket.

E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. K-Flex USA.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.

2.5 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. Metal Jacket:
1. aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.

2.6 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

J. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

K. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

L. For above ambient services, do not install insulation to the following:
   1. Nameplates and data plates.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

   1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   2. Seal longitudinal seams and end joints.

B. Insulation Installation on Pumps:

1. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.6 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Chilled-water pump insulation shall be the following:

1. Flexible Elastomeric: 1 inch thick.

D. Chilled-water air-separator insulation shall be the following:

1. Flexible Elastomeric: 1 inch thick.

E. Heating hot-water air-separator insulation shall be the following:
1. Mineral-Fiber Board: 1-1/2 inch thick.

F. Heating hot-water expansion tank insulation shall be the following:
1. Mineral-Fiber Board: 1-1/2 inch thick.

END OF SECTION 230716

SECTION 230719

MECHANICAL PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping
2. Chilled-water piping
3. Make-up water piping.
4. Heating hot-water piping

B. Section includes insulating the following PLUMBING piping systems:

1. Domestic cold water
2. Domestic hot water and recirculation water
3. Sanitary drain piping where indicated (where serving mechanical room drains exposed at upper floors)
4. Bottom of floor drain bodies and traps, where indicated (for mechanical room drains)
5. Storm drain piping
6. Bottom of roof drain bodies

C. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings:

1. MICA plates or similar graphic illustration.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in DIVISION 15 "Hangers and Supports for HVAC Piping and Equipment." for both hvac and plumbing piping.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Pittsburgh Corning Corporation.

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Aeroflex USA, Inc.
    b. Armacell LLC.
    c. K-Flex USA.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Johns Manville; a Berkshire Hathaway company.
    b. Knauf Insulation.
    c. Owens Corning.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. High Density Rigid Phenolic Pipe Insulation:

1. Products: Subject to compliance with requirements provide one of the following:

   a. Kingspan Tarec Industrial Insulation NV; Koolphen K.
   b. Resolco International BV; Insul-phen.
   c. Trymer; Supercel Phenolic

2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Foster Brand; H. B. Fuller Construction Products.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Aeroflex USA, Inc.
   b. Armacell LLC.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. K-Flex USA.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Foster Brand; H. B. Fuller Construction Products.
b. Knauf Insulation.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.

3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Pittsburgh Corning Corporation.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:
   1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
      a. Sheet and roll stock ready for shop or field sizing.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: Per Identification and Labeling color scheme.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.

3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:
1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below to match existing.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Do not field paint aluminum or stainless-steel jackets.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1” inch thick.

B. Chilled Water, Indoors:

1. Piping located in Mechanical 1017 and 1018, and in concealed chase up to 3rd floor: Insulation shall be the following:

a. Cellular Glass: 2.5 inches thick for piping NPS 1-1/2” and larger.

b. Flexible Elastomeric: 1 inch thick for piping NPS 1” and smaller.

2. All other indoor chilled water piping:

a. Phenolic: 1 inches thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick piping through 1-1/4” diameter, 1-1/2” thick for piping 1-1/2” and larger.

D. Plumbing Piping

1. Domestic Cold water indoors and outdoors: 1" Flexible Elastomeric
2. Domestic hot water and recirculation
    1) 1" diameter and smaller:1" Mineral-Fiber.
    2) 1-1/2" diameter and larger: 1-1/2" Mineral-Fiber.
3. Make-up water to HVAC: 1" Flexible Elastomeric
4. Storm drain piping: All horizontal piping and transition to vertical to be insulated with 1" Flexible Elastomeric.
5. Sanitary drain piping: All horizontal piping serving Mechanical Room Drains at floors 2 and 3 and transition to vertical to be insulated with 1" Flexible Elastomeric.
6. Bottom of floor drains and floor drain bodies in Mechanical Rooms at floors 2 and 3: 1" Flexible Elastomeric.
7. Bottom of roof drain bodies: 1" Flexible Elastomeric.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Indoor Insulated Piping (HVAC and Plumbing) Exposed in Mechanical Rooms:
    1. PVC jacketing, color per 230553 Identification for Piping and Equipment.

END OF SECTION 230719

SECTION 230923

MISC DIRECT DIGITAL CONTROL (DDC) COMPONENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 25 05 01 – Integrated Automation System General Requirements

C. Other Div 23 and 25 specifications

1.2 SUMMARY

A. Section Includes:
1. Miscellaneous control components for the direct digital control system described and specified on the plans and in Div 25 and other Div 23 sections.

1.3 DEFINITIONS

A. Refer to Section 25 05 01 Integrated Automation System General Requirements

1.4 ACTION SUBMITTALS

A. Comply with other submittal requirements in Div 1, 230100 Mechanical General Requirements, and Div 25.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
6. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Shop Drawings:
   1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.8 WARRANTY

A. Manufacturer's Warranty: All components, system software, and parts furnished and installed by the BMS contractor shall be guaranteed against defects in materials and workmanship for 1 years of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BMS contractor at no charge during normal working hours during the warranty period.

PART 2 - PRODUCTS

2.1 ENCLOSURES

A. General Enclosure Requirements:

   1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
   2. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
   3. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
   4. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches high.
   5. Individual wall-mounted double-door enclosures shall not exceed 60 inches wide and 36 inches high.

6. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

2.2 RELAYS

A. General-Purpose Relays:

1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.

2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Relays shall have LED indication and a manual reset and push-to-test button.
7. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
    d. Repeatability: Within 2 percent.
    e. Recycle Time: 45 ms.
    f. Minimum Pulse Width Control: 50 ms.
    g. Power Consumption: 5 VA or less at 120-V ac.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:
1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:
1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:
1. Description:

    a. On-off control and status indication in a single device.
    b. LED status indication of activated relay and current trigger.
    c. Closed-Open-Auto override switch located on the load side of the relay.

2. Performance:

    a. Ambient Temperature: Minus 30 to 140 deg F.

b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

3. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
b. Current Sensor Range: As required by application.
c. Current Set Point: Fixed or adjustable as required by application.
d. Current Sensor Output:

1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
3) Analog, zero- to 5- or 10-V dc.
4) Analog, 4 to 20 mA, loop powered.

4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.3 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.

a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Tag shall consist of white lettering on black background.
3. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
4. Tag shall be fastened with drive pins.
5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Division 26 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

D. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

G. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

END OF SECTION 230923

SECTION 230923.1

CONTROL VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. Cv: Design valve coefficient.

B. DDC: Direct-digital control.

C. NBR: Nitrile butadiene rubber.

D. PTFE: Polytetrafluoroethylene

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Environmental Conditions:

1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

a. Hazardous Locations: Explosion-proof rating for condition.

E. Determine control valve sizes and flow coefficients by ISA 75.01.01.

F. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

G. Selection Criteria:

1. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
2. Valve pattern, three-way or straight through, shall be as indicated on Drawings.

3. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
4. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
5. Fail positions unless otherwise indicated:

    a. Chilled Water: Open.
    b. Heating Hot Water: Open.
6. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
7. Selection shall consider viscosity, flashing, and cavitation corrections.
8. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.

9. Two-position control valves shall be line size unless otherwise indicated.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Belimo Aircontrols (USA), Inc.

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: 300 series stainless steel.
9. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristic: Equal percentage.

B. Ball Valves with Two Ports and Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Belimo Aircontrols (USA), Inc.

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: 300 series stainless steel.
9. Stem and Stem Extension:

   a. Material to match ball.
   b. Blowout-proof design.
   c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

C. Ball Valves with Full Ball and Characterized V-Notch (VB):
1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Bray.

   b. Fisher

2. Performance:

   a. Process Temperature Rating: Minus 20 to plus 500 deg F.
   b. ASME B16.34, Class 600 for NPS 2 and smaller; Class 150 for larger than NPS 2.
   c. Leakage: FCI 70-2, Class VI, bi-directional.
   d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
   e. Rotation: Zero to 90 degrees.
   f. Equal percentage flow characteristic.
   g. Full port with v-notch angle as sized by manufacturer based on cv rating schedule.

3. Face-to-Face Dimension: ASME B16.10 long pattern.
4. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
5. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
6. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
7. Replaceable seat, ball, and shaft packing.
8. Body: Carbon steel.
9. Ball and Shaft: Stainless steel.

10. Ball Seat: RPTFE.
11. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.

    a. Primary Seal: Combination of thrust washer and thrust washer protector.
    b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

12. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.

    a. Primary Seal: Combination of thrust washer and thrust washer protector.
    b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

13. Label each valve with following:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Flow directional arrow.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Belimo.
    b. Keystone; Tyco Flow Control.

2. Performance:

    a. Bi-directional bubble tight shutoff at 250 psig.
    b. Comply with MSS SP-67 or MSS SP-68.
    c. Rotation: Zero to 90 degrees.
    d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.

c. Body and trim materials.
d. Flow arrow.

2.4 DOUBLE-OFFSET HIGH PERFORMANCE BUTTERFLY-STYLE CONTROL VALVES (HPBF)

A. Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. ABZ Valve
b. Bray
c. Fischer

2. Performance:

a. Process Temperature Rating: Minus 200 to plus 849 deg F.
b. ASME B16.34, Class 150 for larger sizes.
c. Complies with MSS SP-68.
d. Leakage: FCI 70-2, Class VI, bi-directional.
e. Rangeability: 100 to 1.
f. Rotation: Zero to 90 degrees.
g. Linear or modified equal percentage flow characteristic as scheduled.

3. Body: Cast steel ASTM A 216/A 216M WCB, fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: ASTM A 351/A 351M, CF3M or CF8M stainless steel.
5. Shaft: 17-4 PH stainless steel.
6. Seat: Reinforced PTFE with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Body rating.
e. Arrow indicating direction of flow.

2.5 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Position indicator and graduated scale on each actuator.

C. Type: Motor operated, with or without gears, electric and electronic.

D. Voltage: 24-V ac.

E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

F. Function properly within a range of 85 to 120 percent of nameplate voltage.

G. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

H. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

I. Two-Position Actuators: Single direction, spring return or reversing type.

J. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable forV dc 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
    d. Programmable Multi-Function:

        1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
        2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

K. Position Feedback:

1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open position.

2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

P. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

Q. Stroke Time:

1. Operate valve from fully closed to fully open within 60 seconds.
2. Operate valve from fully open to fully closed within 60 seconds.
3. Move valve to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.

R. Manual Override:

1. V-notch ball calves to be provided with a hand wheel override.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

a. Laboratory exhaust airstreams.
b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

D. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

E. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

F. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.5 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with valve identification on valve.

3.7 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.

6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12

CONTROL DAMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. DDC: Direct-digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Include diagrams for pneumatic signal and main air tubing.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

2.2 ROUND CONTROL DAMPERS

A. Manufacturers: Provide products by Ruskin or Greenheck.

B. Round Dampers, Flanged Type:

1. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Velocity: Up to 4000 fpm.
c. Temperature: Maximum of 200 deg F.
d. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Size Range: 4 to 60 inches.
2) Material: Galvanized steel.

a) Sizes through 24 Inches in Diameter: 20 gauge
b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.
c) Larger Sizes: 0.31 inch thick.

3) Flanges:

a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.

4) Provide sheet metal stand-off for mounting actuator.

b. Blade: Reinforced circular flat blade constructed of galvanized steel.

c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch galvanized- or stainless- steel bar.

d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.

e. Axle: Plated or stainless steel, mechanically attached to blade.

1) Sizes through 16 Inches: 0.5 inch in diameter.
2) Sizes 18 through 42 Inches: 0.75 inch in diameter.
3) Larger Sizes: 1 inch in diameter.

f. Bearings: Stainless-steel sleeve pressed into frame.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions: See Drawings.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Manufacturer: Belimo, quick acting type.

C. Voltage:

1. 24 V.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

D. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

E. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

F. Two-Position Actuators: Single direction, spring return or reversing type.

G. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
   a. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.

H. Position Feedback:

1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

I. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

J. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

K. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

L. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

M. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

N. Stroke Time:
1. Move damper to failed position within 4 seconds.
2. Select operating speed to be compatible with equipment and system operation.
3. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

O. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. Verify that control dampers are installed correctly for flow direction.
6. Verify that proper blade alignment, either parallel or opposed, has been provided.
7. Verify that damper frame attachment is properly secured and sealed.
8. Verify that damper actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that damper blade travel is unobstructed.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 230923.14

FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Airflow measurement
2. Waterflow measurement.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

C. PEEK: polyetheretherketone.

D. PTFE: Polytetrafluoroethylene.

E. PPS: Polyphenylene sulfide.

F. RS-485: A TIA standard for multipoint communications using two twisted pairs.

G. RTD: Resistance temperature detector.

H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Liquid and steam sensors, meters, and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

2.3 AIRFLOW SENSORS:

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

B. Thermal Airflow Station:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Ebtron, Inc.

2. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
3. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.
4. Performance:

    a. Capable of independently processing up to 16 independently wired sensor assemblies.
    b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
    c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.

d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range.

1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.

h. Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.
i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 2 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

5. Sensor Assemblies:

a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
c. Thermistor leads shall be protected and not exposed to the environment.
d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.
g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

6. Casing:

a. Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.
b. Material: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.

c. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.
d. Casing Depth: At least 8 inches.
e. Include casing inlet and discharge connections with a minimum1.5-inch face flange.

7. Transmitter:

a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

a) Integral protection from transients and power surges.
b) Circuitry to ensure reset after power disruption, transients, and brownouts.
c) Integral transformer to convert field power source to operating voltage required by instrument.

c. Remote Signal Interface:

1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, field selectable,.

2.4 INSERTION MAGNETIC FLOW METERS

A. Chilled Water Flow meters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Onicon F-3500

2. Description: bi-directional flowmeter with sensor and transmitter.
3. Flow Range: 35-7050 gpm when installed in 10-inch diameter piping.
4. Sensor: 316 stainless steel wetted parts, for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute

a. Design: designed to be installed in hot tapped ball valve
b. Minimum Pressure Rating: 400psig
c. Temperature Rating: 15 to 250-F.

5. Accuracy: Plus or minus 1 % of reading at 2 to 20 fps (10:1 range).
6. Directional contact output.
7. Operating Instructions: Include complete instructions with each flowmeter.
8. Two-year warranty.
9. Provide hot-tap design, and install with 1” thread-o-let, 1” close nipple, 1” full port ball valve, ball valve adapter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated.

D. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. DO NOT mount transmitter display to ductwork.
6. Transmitter display to be installed at 7 ft AFF maximum
7. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Waterflow sensors:
1. Install sensors in straight sections of piping with manufacturer-recommended straight pipe upstream and downstream of sensor. Provide transitions in pipe as required if plans call for reduction in pipe size at the meter.
2. Installed sensors shall be accessible for inspection and service. Install such that meter can be removed for replacement and cleaning.

3.6 IDENTIFICATION

A. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

D. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 230923.14

SECTION 230923.16

GAS INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes the Following Gas Instruments:

1. Carbon-dioxide sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Installation instructions, including factor affecting performance.
3. Product description with complete technical data, performance curves, product specification sheets.

B. Shop Drawings:

1. Include plans, elevations, sections, and [**mounting**]details.
2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.

B. Product Test Reports: For each product, for tests performed by [**manufacturer and witnessed by a qualified testing agency**] [**a qualified testing agency**].

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

C. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

D. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F (minus 4 to 43 deg C).
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

E. Provide calibration kit. Turn over to Owner at start of warranty period.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.
    c. **<Insert requirements>**.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of [**2**] [**3**] <**Insert number**> percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m)above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches (1.5 m).

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.6 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.8 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include [**three**] [**six**] [**nine**] [**12**] months' full maintenance by [**skilled employees of gas system and equipment Installer**] [**manufacturer's authorized service representative**]. Include [**monthly**] [**quarterly**] [**semiannual**] [**annual**] preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 230923.16

SECTION 230923.19

MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes moisture switches, sensors, and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MOISTURE SWITCHES

A. Humidistat for Space Applications:

1. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Relative Humidity Range: 10 to 90 percent.
b. Relative Humidity Differential: 5 percent.
c. Ambient Temperature: 40 to 135 deg F (4 to 57 deg C).
d. Voltage: 24-V ac.
e. Pilot Duty: 60 VA.
f. Switch Type: SPDT snap switch.

3. Construction:

a. Enclosure: Plastic, NEMA 250, Type 1.
b. Electrical Connections: Cable, 6 inches (150 mm) long.

2.2 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F (16 to 25 deg C).
b. Relative Humidity Range: Zero to 100 percent.
c. Factory calibrated and NIST traceable with certificate included.

2. Construction:

a. Provide housing with integral sensor for room applications.
b. Provide housing with remote sensor probe for ducted applications.

1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches (50 mm) long for duct-mounted applications.
2) Provide sensor with cable for field installation in conduit.

3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.

c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be ABS/PC plastic or powder-coated aluminum.
e. Housing Classification: NEMA 250, Type 4 or 4X.
f. Provide housing with wall-mounting plate.

3. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.
4. Provide unit with a digital display of relative humidity in percent.

B. Sensor and Transmitter without Display:

1. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 3 percent from 90 to 95 percent relative humidity when operating at 68 deg F (20 deg C).
b. Relative Humidity Range:

1) Duct: Zero to 100 percent.
2) Space: Zero to 95 percent relative.

c. Factory calibrated and NIST traceable with certificate included.

2. Construction for Space Applications:

a. Housing with integral sensor.
b. Housing shall be ABS plastic or powder-coated aluminum.
c. Enclosure: NEMA 250, Type 4.
d. Provide housing with a wall-mounting plate.

3. Construction for Duct and Equipment Applications:

a. Housing with integral sensor.
b. Duct Sensor Body: 300 series stainless steel.
c. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be cast aluminum.
e. Enclosure: NEMA 250, Type 4.

4. Output Signal: Two-wire, 4- to 20-mA output signal with drive capacity of at least 500 ohms at 24-V dc.

C. Combination Humidity and Temperature Sensor and Transmitter with Display:

1. Description:

a. Factory package consisting of humidity and temperature sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
b. Each transmitter shall be individually calibrated and provided with NIST traceable calibration certifications.
c. Provide a service cable for connecting to a notebook computer and Microsoft Windows compatible software.

2. Display:

a. Alphanumeric display of the following on the face of the enclosure:

1) Percent relative humidity.
2) Absolute humidity.
3) Mixing ratio.
4) Dry-bulb temperature.
5) Wet-bulb temperature.
6) Dew point temperature.
7) Enthalpy.

b. Visual display of measurement trends, and minimum and maximum values over a one-year period.

3. Electronics Enclosure:

a. Integral to sensors for wall- (room-)mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
b. NEMA 250, Type 4 or 4X.
c. Labeled terminal strip for field wiring connections.
d. ?-inch ((16-mm))trade size threaded conduit connection.

4. Programming:

a. Transmitter parameters shall be field programmable through keypad on the face of the enclosure.
b. Programmed parameters shall be stored in nonvolatile EEPROM.

5. Output Signals:

a. Three Analog Outputs: 4 to 20 mA or zero to 10-V dc for each output.

6. Temperature Sensor:

a. Temperature range matched to application, but not less than minus 40 to 140 deg F (minus 40 to 60 deg C).
b. Within 0.5 deg F (0.3 deg C) accuracy over the temperature range of 50 to 100 deg F (10 to 38 deg C) and within 1 deg F (0.6 deg C) over the remainder of the range.
c. Provide duct installation kit for duct applications.

7. Humidity Sensor:

a. Relative Humidity Measurement Range: Zero to 100 percent.
b. Response time in still air within 40 seconds.
c. Accuracy including non-linearity, hysteresis, and repeatability:

1) For Temperature Between 59 and 77 Deg F (15 to 25 Deg C) and Relative Humidity between Zero and 90 Percent: Within 1 percent.
2) For Temperature between 59 and 77 Deg F (15 to 25 Deg C) and Relative Humidity between 90 and 100 Percent: Within 1.7 percent.
3) For Temperature between Minus 4 and 104 Deg F (Minus 20 to 40 Deg C): Within 1 percent plus 0.008 times relative humidity reading.
4) For Temperature between Minus 40 and 356 Deg F (Minus 40 to 180 Deg C): Within 1.5 percent plus 0.015 times the relative humidity reading.

d. Sintered, stainless-steel filter, protecting sensor.
e. Provide duct installation kit for duct applications.

8. Power Supply:

a. Field Power: 120-V ac, 60 Hz unless otherwise required by the application.
b. Internal Power: As required by transmitter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

C. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 MOISTURE INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inches ((1.1 to 1.6 m))above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches (1.5 m).

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 230923.19

SECTION 230923.23

PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air-pressure transmitters.
2. Liquid-pressure transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
3. Size and location of wall access panels for instruments installed behind walls.
4. Size and location of ceiling access panels for instruments installed in accessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For each product requiring test performed by a qualified testing agency.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument-installed location shall dictate following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 3x.
b. Indoors, Heated and Air-Conditioned: Type 1.
c. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 1.
2) Air-Moving Equipment Rooms: Type 1.

d. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
e. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

2.2 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:

1. Description:

a. Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
c. Select instrument range based on application. Range shall be approximately 2 times set point.

2. Performance:
a. Media Compatibility Dry air or inert gas
b. Input Power 12-30VDC, or 24VAC nominal
c. Output Field-selectable: 2-wire, loop-powered 4-20mA (DC only, clipped and capped) or 3-wire 0-5V/0-10V
d. Pressure Ranges: Unidirectional: 0.1/0.25/0.5/1.0” W.C. F.S. (25 pa/50 pa/100 pa/250 pa, F.S.), switch selectable; Bidirectional: ±0.1/±0.25/±0.5/±1.0” W.C. F.S. (±25 pa/±50 pa/±100 pa/±250 pa, F.S.), switch selectable
e. Response Time Standard: T95 in 20 sec, Fast: T95 in 2 sec, switch selectable
f. Mode Unidirectional or bidirectional, switch selectable
g. Display (option) Signed 3-1/2 digit LCD, indicates pressure, overrange indicator
h. Proof Pressure 3 psid (20.6kPa)
i. Burst Pressure 5 psid (34.5kPa)
j. Accuracy ±1% F.S. of selected range (combined linearity and hysteresis)
k. Temperature Effect 1" 0.05%/°C; 10"
l. Zero Drift (1-year) 1" 2.0% max.
m. Zero Adjust Pushbutton auto-zero and digital input (2-pos terminal block)
n. Operating Environment 0°- 60°C (32° to 140°F); 0 to 90% RH non-condensing
o. Fittings Brass barb; 0.24” (6.1mm) o.d.
p. Physical UL 94 V-O Fire Retardant ABS

3. Controller Programming through Menu Keys to Access Five Menus:

a. Security level.
b. Pressure, velocity, or flow application.
c. Engineering units.
d. K-factor for use with flow application.
e. Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
f. View high and low readings.
g. Digital dampening for smoothing erratic applications.
h. Scaling of analog output to fit range and field calibration.

4. Display:

a. Digital, four-digit display with backlight, with 0.4-inch- (10-mm-) high alphanumeric characters.
b. Four indicators; two for set point and two for alarm status.

5. Operator Interface:

a. Set-point adjustment through keypad on face of instrument.
b. Zero and span adjustments accessible through menu.
c. Programming through keypad.

6. Analog Output Signal:

a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into a 900-ohm load.

7. Digital Output Signal:

a. Two SPDT relays.
b. Each rated for one amp at 30-V ac or dc.

8. Construction:

a. Die cast-aluminum casing and bezel.
b. Threaded, NPS 1/8 (DN 6) connections on side and back.
c. Vertical plane mounting.
d. NEMA 250, Type 1.
e. Nominal 4-inch- (100-mm-) diameter face.
f. Mounting Bracket: Appropriate for installation.

2.3 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:

1. Performance:

a. Range: Approximately 2 times set point.
b. Span: Adjustable plus or minus one milliamp, noninteractive.

c. Accuracy: Within 0.25 percent of full scale.
d. Pressure: Maximum operating pressure 2.5 times range.
e. Temperature Limits: Zero to 200 deg F (Minus 18 to 79 deg C).
f. Compensate Temperature Limits: 30 to 150 deg F (Minus 1 to 66 deg C).
g. Thermal Effects: 0.02 percent of full scale per degree F.
h. Response Time: 30 to 50 ms.
i. Shock and vibration shall not harm the transmitter.

2. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into 1000-ohm load.

3. Operator Interface:

a. Zero and span adjustments located behind cover.
b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

4. Construction:

a. Aluminum and stainless-steel enclosure with removable cover.
b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
c. Threaded, NPS 1/4 (DN 10) process connections on side of instrument enclosure.
d. Knock out for 1/2-inch (16-mm) nominal conduit connection on side of instrument enclosure.
e. Screw terminal block for wire connections.
f. NEMA 250, Type 1.
g. Mounting Bracket: Appropriate for installation.

5. Three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 (DN 10) process connections.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PRESSURE INSTRUMENT APPLICATIONS

A. Air-Pressure Differential Transmitters:

1. Duct, Supply System: Air-pressure differential indicating transmitter, switch, and controller.
2. Space, Building Pressurization Control System,: Air-pressure differential indicating transmitter, switch, and controller.

B. Liquid-Pressure Differential Transmitters:

1. Hot Water System: Liquid-pressure differential transmitter.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.

2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

3.4 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4 (DN 20). Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed

instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 230923.23

SECTION 230923.2

TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air temperature sensors
2. Liquid temperature sensors.
3. Liquid temperature RTD transmitters.

B. Related Requirements:

1. Section 15975 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. RTD: Resistance temperature detector.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

a. Outdoors, Unprotected: Type 4.
b. Indoors, Heated and Air Conditioned: Type 1.
c. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 12.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

a. Range: Minus 50 to 275 deg F.
b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
c. Repeatability: Within 0.5 deg F.
d. Self-Heating: Negligible.

4. Transmitter Requirements:

a. Transmitter required for each 100-ohm RTD.
b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. 1000-ohm platinum RTD.
2. Thermistor:

a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.

3. Temperature Transmitter Requirements:

a. Mating transmitter required with each 100-ohm RTD.
b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

4. Provide digital display of sensed temperature.
5. Provide sensor with local control.

a. Local override to turn HVAC on.
b. Local adjustment of temperature set point.
c. Both features shall be capable of manual override through control system operator.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Operating Temperature Range: 15 to 55 deg F.
b. Temperature Differential: 5 deg F, non-adjustable and additive.
c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
d. Sensing Element Maximum Temperature: 250 deg F.
e. Voltage: 120-V ac.
f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inchsection along element length.

3. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 feetlong.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch trade size.

2.4 AIR TEMPERATURE RTD TRANSMITTERS

A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

B. House electronics in NEMA 250 enclosure.

1. Duct: Type 1.
2. Outdoor: Type 4.
3. Space: Type 1.

C. Conduit Connection: 1/2-inch

D. Functional Characteristics:

1. Input:
   a. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):

   a. Space: 40 to 90 deg F.
   b. Supply Air Cooling and Heating: 40 to 120 deg F.
   c. Supply Air Cooling Only: 40 to 90 deg F.
   d. Supply Air Heating Only: 40 to 120 deg F.
   e. Exhaust Air: 50 to 100 deg F.
   f. Return Air: 50 to 100 deg F.
   g. Mixed Air: Minus 40 to 140 deg F.
   h. Outdoor: Minus 40 to 140 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc .
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.5 LIQUID TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

1. Description:

   a. Platinum with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

b. Encase RTD in a stainless-steel sheath with a 0.25-inch OD.
c. Sensor Length: 4, 6, or 8 inchesas required by application.
d. Process Connection: Threaded, NPS 1/2
e. Two-stranded copper lead wires.
f. Powder-coated steel enclosure, NEMA 250, Type 4.
g. Conduit Connection: 1/2-inch
h. Performance Characteristics:

1) Range: Minus 40 to 210 deg F.
2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:

1. Stem: stepped shank formed from solid bar stock.
2. Material: Brass.
3. Process Connection: Threaded, NPS 3/4.
4. Sensor Connection: Threaded, NPS 1/2.
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: 4, 6, or 8 inchesas required by application.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.6 LIQUID TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

A. House electronics in NEMA 250, Type 4 enclosure.

B. Enclosure Connection: 1/2-inch trade size.

C. Functional Characteristics:

1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
2. Default Span (Adjustable):

a. Chilled Water: Zero to 100 deg F.
b. Condenser Water: Zero to 120 deg F.
c. Heating Hot Water: 32 to 212 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

D. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.

3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
2) Do not begin installation without submittal approval of mounting location.

c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inchesabove the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.

2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell.

2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:

    a. Install reducers to increase pipe size to NPS 4at point of thermowell installation.
    b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
    c. Minimum insertion depth shall be 2-1/2 inches.

4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor.

3.4 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.5 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

END OF SECTION 230923.27

SECTION 231123

FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Pipes and fittings, above and below ground.
2. Piping specialties.
3. Piping joining materials.
4. Valves.
5. Pressure regulators.
6. Meters.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 65 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

C. Natural-Gas System Pressure outside of Buildings: No more than 5 psig.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   3. Pressure regulators. Indicate pressure ratings and capacities.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.9 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Architect no fewer than 10 days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without Architect's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   3. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

      a. Material Group: 1.1.
      b. End Connections: Threaded or butt welding to match pipe.
      c. Lapped Face: Not permitted underground.
      d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
      e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

B. PE Pipe: ASTM D 2513, SDR 11.
   1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
   2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

      a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
      b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.
      c. Aboveground Portion: PE transition fitting.
      d. Outlet shall be threaded or flanged or suitable for welded connection.
      e. Tracer wire connection.
      f. Ultraviolet shield.
      g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

   4. Plastic Mechanical Couplings, NPS 1-1/2 and Smaller: Capable of joining PE pipe to PE pipe.

      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Lyall, R. W. & Company, Inc.
         2) Mueller Co.; Gas Products Div.
         3) Perfection Corporation; a subsidiary of American Meter Company.

      b. PE body with molded-in, stainless-steel support ring.
      c. Buna-nitrile seals.
      d. Acetal collets.
      e. Electro-zinc-plated steel stiffener

2.2 PIPING SPECIALTIES

A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 125 psig.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   2. Threaded Ends: Comply with ASME B1.20.1.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
   1. CWP Rating: 125 psig.
   2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

C. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
   1. Body: Cast iron, complying with ASTM A 126, Class B.
   2. Plug: Bronze or nickel-plated cast iron.
   3. Seat: Coated with thermoplastic.
   4. Stem Seal: Compatible with natural gas.
   5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   6. Operator: Square head or lug type with tamperproof feature where indicated.
   7. Pressure Class: 125 psig.
   8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:
1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Regulators: Comply with ANSI Z21.80.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. American Meter Company (Basis)
    b. Fisher Control Valves & Instruments;.
    c. Maxitrol Company.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: Refer to detail on plans.

C. Line Regulators (to be used for each appliance): Comply with ANSI Z21.80.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Maxitrol Company
    b. Pietro Fiorentini Governor Series

2. Type: High Capacity type. Low, or standard capacity, not permitted.
3. Body and Diaphragm Case: Cast iron or die-cast aluminum.
4. Springs: Zinc-plated steel; interchangeable.
5. Diaphragm Plate: Zinc-plated steel.
6. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
7. Orifice: Aluminum; interchangeable.
8. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
9. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
10. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Overpressure Protection Device: Factory mounted on pressure regulator.

12. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening for applications outdoors.
13. Inlet filter.
14. Integral Vent Limiter.
15. Turndown: 500:1

D. Maximum Inlet Pressure: Refer to detail on plans.

2.6 GAS METERS

A. Refer to detail on plans.

2.7 LABELING AND IDENTIFYING

A. Detectable Warning Tape (Tracer tape): Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

A. Install underground, natural-gas piping buried at least 18 inches below finished grade.

B. Install underground, PE, natural-gas piping according to ASTM D 2774.

C. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

3.4 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

P. Connect branch piping from top or side of horizontal piping.

Q. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

R. Do not use natural-gas piping as grounding electrode.

S. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

T. Install pressure gage tapping and valve cock upstream and downstream from each line regulator.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 15060 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
   5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

C. Install hangers for horizontal drawn-temper copper tubing (used for regulator relief) with the following maximum spacing and minimum rod sizes:
   1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch.
   2. NPS 1/2 and NPS 5/8: Maximum span, 72 inches; minimum rod size, 3/8 inch.
   3. NPS 3/4 and NPS 7/8: Maximum span, 84 inches; minimum rod size, 3/8 inch.
   4. NPS 1: Maximum span, 96 inches; minimum rod size, 3/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps (Dirt/Drip legs): Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 PAINTING

A. Paint exposed, interior metal piping exposed in a space and all outdoor piping, valves, service regulators, service meters and meter bars, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI INT 5.1E.
      a. Prime Coat: Quick-drying alkyd metal primer.
      b. Intermediate Coat: Interior alkyd matching topcoat.
      c. Topcoat: Interior alkyd (gloss).
      d. Color: Interior – Yellow, Exterior – grey.

B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to the 2021 International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

END OF SECTION 231123

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.
2. Chilled water piping.
3. Air-vent piping.
4. Makeup-water piping.

1.3 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current certification and has been updated within 24 months prior to project start date .
3. Welder’s Certificate: Provide certificate of compliance indicating approval of welders prior to any welding. Certificate must be obtained from an independent certification agency and must include welder’s picture and I.D. number. Test must be for 6G position, E-6010 root and E-7018 filler. Welder must stamp each weld with his I.D

D. Ultrasonic Testing: All pipe welds shall undergo ultrasonic testing prior to insulation. Owner shall provide ultrasonic testing services. Test and pass/fail criteria shall be per ASME B31.3 paragraph 344.6.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 120 psig at 200 deg F.
2. Chilled-Water Piping: 120 psig at 200 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Air-Vent Piping: 200 deg F.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Watts; a Watts Water Technologies company.
b. Wilkins.
c. Zurn Industries, LLC.

2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Elster Perfection Corporation.
    b. Grinnell Mechanical Products.
    c. Matco-Norca.
    d. Precision Plumbing Products.
    e. Victaulic Company.

2. Description:

    a. Standard: IAPMO PS 66.
    b. Electroplated steel nipple, complying with ASTM F 1545.
    a. Pressure Rating: 125 psig minimum at 180 deg F.
    b. End Connections: Male threaded or grooved.
    c. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed or pressure-seal joints.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:

E. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

F. Makeup-water piping installed aboveground shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

G. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

H. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to valves Sections.

Q. Install nipples in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.

4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232113.13

UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cased piping system.

1.3 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:

1. Chilled-Water Piping: 150 psig at 200 deg F.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Conduit piping.
2. Cased piping.
3. Loose-fill insulation.

B. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer.

1. Calculate requirements for expansion compensation for underground piping.
2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
3. Show pipe sizes, locations, and elevations. Show piping in trench, conduit, and cased pipe with details showing clearances between piping, and show insulation thickness.

1.5 INFORMATIONAL SUBMITTALS

A. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and at vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing hydronic piping.

B. Qualification Data: For qualified Installer.

C. Welding certificates.

D. Material Test Reports: For cased piping.

E. Source quality-control reports.

F. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31.9, "Building Services Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 CASED PIPING SYSTEM

A. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.

1. Subject to compliance with the plans and specifications, products to be provided by the following or preapproved equal:
   a. Thermacor

B. Carrier Pipe: Schedule 40, steel pipe and fittings.

C. Carrier Pipe Insulation:

1. Polyurethane Foam Pipe Insulation: Rigid, cellular, high-pressure injected between carrier pipe and jacket.

    a. Comply with ASTM C 591; thermal conductivity (k-value) shall not exceed 0.14 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.

D. Casing: HDPE.

E. Casing accessories include the following:

1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
2. Expansion Blanket: Elastomeric foam, formed to fit over piping.
3. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.

F. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

PART 3 - EXECUTION

3.1 PIPING APPLICATION

A. Chilled-Water Piping:

1. NPS 2-1/2 and larger shall be the following:

    a. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

2. Cased piping with polyurethane carrier-pipe insulation.

    a. Piping Insulation Thickness: 2 inches.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Remove standing water in the bottom of trench.

C. Do not backfill piping trench until field quality-control testing has been completed and results approved.

D. Install piping at uniform grade of 0.2 percent. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points and elsewhere as required for system drainage. Install manual air vents at high points.

E. In conduits, install drain valves at low points and manual air vents at high points.

F. Install components with pressure rating equal to or greater than system operating pressure.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. See Section 230517 "Sleeves and Sleeve Seals for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.

J. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

K. See Section 264200 "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.

3.3 JOINT CONSTRUCTION

A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 35, "Pipe and Tubing," using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

J. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.4 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:

   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
   c. Use vents installed at high points to release trapped air while filling system.

2. Test hydronic piping as follows:

   a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
   b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.

3. Test conduit as follows:

   a. Seal vents and drains and subject conduit to 15 psig for four hours with no loss of pressure. Repair leaks and retest as required.

E. Prepare test and inspection reports.

END OF SECTION 232113.13

SECTION 232116

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Makeup-water piping.
4. Air-vent piping.
5. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Comply with requirements specified in other Sections

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Armstrong Pumps, Inc.
   2. Bell & Gossett.
   3. Flow Design.
   4. Griswold.
   5. Taco.

C. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   2. Ball: stainless steel.
   3. Plug: Resin.
   4. Seat: PTFE.
   5. End Connections: Threaded or socket.
   6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   7. Handle Style: Lever, with memory stop to retain set position.
   8. CWP Rating: Minimum 125 psig (860 kPa).
   9. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   1. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
   2. Ball: stainless steel.
   3. Stem Seals: EPDM O-rings.
   4. Disc: Glass and carbon-filled PTFE.
   5. Seat: PTFE.
   6. End Connections: Flanged or grooved.
   7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   8. Handle Style: Lever, with memory stop to retain set position.
   9. CWP Rating: Minimum 125 psig (860 kPa).
   10. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
   1. Body: Bronze or brass.
   2. Disc: Glass and carbon-filled PTFE.
   3. Seat: Brass.

4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Inlet Strainer: stainless steel or bronze, removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: stainless steel or bronze, removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:
1. Body: Cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2 (DN 15) or greater where required.
5. Discharge Connection: NPS 1/4 (DN 8), piped to floor drain.
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

C. Bladder-Type Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. In-Line Air-Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett.
   c. Grundfos
   d. Spirotherm
   e. Taco.
   f. Thrush

2. Tank: Removable head, cast iron with an integral weir constructed to decelerate system flow to maximize air and dirt separation.
3. Maximum Working Pressure: Up to 175 psig (1207 kPa).
4. Velocity: Standard
5. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

C. Install check valves at each pump discharge and elsewhere as required to control flow direction.

D. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air-dirt separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install expansion tanks on the floor on concrete housekeeping pad. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Separately coupled, vertical in-line centrifugal pumps, indoors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

   1. Show pump layout and connections.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 SEPARATELY COUPLED, VERTICAL IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Pumps, Inc.
2. Aurora Pump; Pentair Ltd.
3. Grundfos Pumps Corporation.
4. Bell & Gossett.
5. Paco
6. Patterson Pump Co.
7. Taco.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and companion-flange connections.
2. Impeller: ASTM B 584, cast bronze or stainless steel; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal, rated to 200°F maximum. consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Viton gasket.
5. Pump Bearings: Permanently lubricated ball bearings.

D. Shaft Coupling: Rigid spacer type, high tensile aluminum or cast iron. Design coupling for easy removal on site to reveal space between pump and motor shaft. Ensure revealed space is sufficient for removal of mechanical seal components without disturbing pump, controls or motor. Include coupling guard.

E. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Totally enclosed, fan cooled
b. Enclosure Materials: Cast iron.
c. Motor Bearings: Permanently lubricated ball bearings.

d. Efficiency: NEMA Premium efficiency To NEMA MG-1 table 12.12, variable speed drive duty.
e. Service Factor: 1.15.

2.2 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig (1204-kPa) pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Support pumps per manufacturers requirements.

3.3 CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Connect wiring according to Section 260000 "Electrical."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 232513

WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:

1. Manual chemical-feed equipment.
2. Chemicals.

B. Systems included

1. New hydronic hot water closed-loop systems
2. New hydronic chilled water systems – chemically treat prior to opening building to campus system

1.3 DEFINITIONS

A. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. Chemical test equipment.
3. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.

1. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Other Informational Submittals:
   1. Water Analysis: Illustrate water quality available at Project site.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Hydronic systems, including hot-water heating and chilled water, shall have the following water qualities after treatment is complete, or as recommended by chemical treatment provider:

   1. Acceptable pH: The pH of the closed loop should always be higher than the make-up water pH. Water pH shall not be below 8 or above 10.3.
   2. Total Iron: Maintain a maximum value of 5 ppm.
   3. Ferrous Iron: Maintain a maximum value of 2 ppm
   4. Copper: Maintain a maximum value of 0.5 ppm

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 5 gal. (19 L)
2. Minimum Working Pressure: 125 psig (860 kPa).

2.3 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Bypass Feeders: Install in closed hydronic systems, including hot-water heating and chilled water, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install a full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
3. Install a swing check on the inlet after the isolation valve.

3.3 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties."

C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.12 "Ball Valves for HVAC Piping."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Inspect field-assembled components and equipment installation, including piping.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Acidity and Alkalinity: ASTM D1067.
3. Iron: ASTM D1068.
4. Water Hardness: ASTM D1126.

END OF SECTION 232513

SECTION 233113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealant and gaskets.
5. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Sheet Metal Material
2. Liners and adhesives.
3. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of main all duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
13. Ductwork systems for
    a. All medium pressure ductwork.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure

class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eastern Sheet Metal.
    b. United-McGill AirFlow LLC.
    c. SEMCO Incorporated.
    d. Sheet Metal Connectors, Inc.
    e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.
3. Finishes for Surfaces to be field painted shall be suitable for field painting. – This applies to all ductwork exposed in occupied spaces.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
9. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
10. Service: Indoor or outdoor.
11. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

D. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in the General Notes on the plans according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
   a. Supply Ducts between AHUs and Terminal units.
   b. All Exhaust ductwork.
   c. All ductwork concealed in a chase.
   d. All ductwork concealed above hard ceilings.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.

B. Supply Ducts, galvanized sheet metal:

1. Ducts Connected to Fan Coil Units and Terminal Units:

a. Pressure Class: Positive 1-inch wg.

2. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive 4-inch wg or 1-inch greater than TSP of AHU, whichever is higher.

C. Return Ducts, galvanized sheet metal:

1. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.

D. Exhaust and Outdoor-air Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air,

a. Galvanized sheet metal
b. Pressure Class: Negative 1-inch wg.

A. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

B. Ibow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Velocity 1000 fpm or Lower:

      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.

   b. Velocity 1000 to 1500 fpm:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

   c. Velocity 1500 fpm or Higher:

      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

C. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Fire dampers.
3. Smoke dampers.
4. Combination fire/smoke dampers
5. Flange connectors.
6. Turning vanes.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Flexmaster U.S.A., Inc.

b. McGill AirFlow LLC.
c. Nailor Industries Inc.
d. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.

3. Suitable for horizontal or vertical applications.
4. Frames:

a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

a. Oil-impregnated bronze.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.

2.4 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Ruskin Company.

A. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

C. Fire Rating: Refer to Architectural Life Safety plans, and providing rating as required for wall to which the damper is installed.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

H. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.5 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA Publication 511.
2. Leakage:
   a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Suitable for horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:

    a. Hat shaped.
    b. Galvanized sheet steel, with interlocking, gusseted corners and mounting flange.
    c. Gauge in accordance with UL listing.

4. Blades:

    a. Roll-formed, horizontal, airfoil, galvanized sheet steel.
    b. Maximum width and gauge in accordance with UL listing.

5. Blade Edging Seals:

    a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage is to be mounted out of airstream.
8. Bearings:

    a. Stainless steel sleeve.

E. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application; gauge in accordance with UL listing.

F. Damper Actuator - Electric:

1. Electric - 120 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position with fail-safe spring return.

    a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.
    c. Minimum 90-degree drive rotation.

5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:

a. Temperature: Minus 40 to plus 130 deg F.
b. Humidity: 5 to 95 percent relative humidity noncondensing.

7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

G. Accessories:

1. Auxiliary switches for signaling fan control or position indication.
2. Momentary test switch, damper mounted.
3. Smoke Detectors by DIV 26

2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Ruskin Company.

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

D. Fire Rating: Per Architects Life Safety Plans by location.

E. Performance:

1. AMCA Certification: Test and rate in accordance with AMCE Publication 511.
2. Leakage:

a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 in. wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

F. Construction:

1. Suitable or horizontal or vertical airflow applications.
2. Linkage out of airstream.

3. Frame:

    a. Hat shaped.
    b. Galvanized sheet steel, with interlocking, gusseted or mechanically attached corners and mounting flange.
    c. Gauge is to be in accordance with UL listing.

4. Blades:

    a. Roll-formed, horizontal,, galvanized sheet steel.
    b. Maximum width and gauge in accordance with UL listing.

5. Blade Edging Seals:

    a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch-diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
8. Bearings:

    a. Oil-impregnated bronze.

G. Mounting Sleeve:

1. Factory installed, galvanized sheet steel.
2. Length to suit wall or floor application.
3. Gauge in accordance with UL listing.

H. Heat-Responsive Device:

1. Replaceable, 165 deg F rated, fusible links.

I. Damper Actuator - Electric:

1. Electric - 120 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position with fail-safe spring return.

    a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.
    c. Minimum 90-degree drive rotation.

5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:

    a. Temperature: Minus 40 to plus 130 deg F.
    b. Humidity: 5 to 95 percent relative humidity noncondensing.

7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

J. Controllers, Electrical Devices, and Wiring:
1. Electrical Connection: 115 V, single phase, 60 Hz

K. Smoke Detectors by DIV 26.

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aero-Dyne Sound Control Co.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Hardcast, Inc.
5. SEMCO LLC.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.

b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches.
d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Hardcast, Inc.
4. Ventfabrics, Inc.
5. Ward Industries; a brand of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inchsteel sleeve, continuously welded at all joints and 1/2-inch-diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
2. Elsewhere as indicated, refer to Metal Ducts section for access panels required for Grease Ductwork.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:
1. 12 by 12 inches minimum.

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. Install duct test holes where required for testing and balancing purposes.

O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

SECTION 233346

FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flexmaster U.S.A., Inc.
2. Flex-Tek Group.
3. McGill AirFlow LLC.
4. Ward Industries; a brand of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect diffusers to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

D. Connect flexible ducts to metal ducts with liquid adhesive plus tape.

E. Install duct test holes where required for testing and balancing purposes.

F. Installation:

1. Install ducts fully extended.

2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions. Ducts may not rest on ceilings or any other item other than joists or structural supports.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

SECTION 233423

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators, downblast.
2. Square Inline Fan.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For fan supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   2. Wind- Restraint Details: Detail fabrication and attachment of wind restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Belts: One set(s) for each belt-driven unit.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer in the State of Alabama, to design mounting and restraints for equipment, including comprehensive engineering analysis.

1. Design equipment supports to comply with wind performance requirements.

B. Wind-Restraint Performance:

1. Basic Wind Speed: 120 mph.
2. Building Classification Category: III.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Subject to compliance with the plans and specifications, provide products by one of the following:

1. Cook
2. Greenheck

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:
1. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
2. Gravity Backdraft Dampers: Mounted in curb base.

F. Roof Curbs: Galvanized steel; mitered and welded corners; double wall with 1" thick insulation; Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Metal Liner: Galvanized steel.

2.3 SQUARE IN-LINE CENTRIFUGAL FANS

A. Description: Square in-line centrifugal fans.

B. Housing:

1. Housing Material: Aluminum.
2. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

F. Motor Enclosure: TEFC.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.

C. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive, with shaft grounding rings.

2.5 SOURCE QUALITY CONTROL

A. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

SECTION 233600

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Shutoff, single-duct air terminal units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Instructions for resetting minimum and maximum air volumes.
    b. Instructions for adjusting software set points.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier
2. Daikin McQuay.
3. ENVIRO-TEC.
4. Price Industries.
5. Titus.
6. Trane.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 22 gauge thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 6-inch wg inlet static pressure.

2. Damper Position: Normally open.

E. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

F. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

G. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.

2.3 CASING LINER

A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 3/4 inch (19 mm).
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.

C. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.3 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Louver Face directional supply diffusers.
2. Louver Face Supply Grilles, double deflection.
3. Round exposed directional supply diffusers
4. Linear slot diffusers.
5. Louvered Return Grilles.
6. Louvered Exhaust Registers.

B. Related Sections:

1. Division 23 Section "Air Duct Accessories" for fire dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL – COLOR AND FINISH

A. For all diffusers, registers, and grilles, custom colors are required in spaces as specified on the Architectural finish plans and RCP schedules. If custom colors is not specified on the Architectural plans, provide color as specified in this section.

2.2 CEILING DIFFUSERS

A. Louver Face Directional Supply Diffuser:

1. Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. METALAIRE, Inc.
    c. Nailor Industries Inc.
    d. Price Industries AMDA.
    e. Titus TDCA
    f. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Aluminum.
4. Face Syle: Louvered.
5. Finish: Powder coat, white
6. Mounting: Surface or T-bar per the reflected ceiling plans.
7. Pattern: One-way, Two-way, Two-way corner, Three-way, Four-way, core style as indicated on the plans.
8. Dampers: Opposed blade.
9. Accessories:

    a. Square to round neck adaptor where round runout is indicated on the plans.

2.3 LINEAR SLOT DIFFUSERS

A. Basis of Design: Price Adjusta-slot.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material - Shell: Aluminum, externally insulated.

D. Material - Pattern Controller and Tees: Aluminum.

E. Finish - Face and Shell: Baked enamel, black.

F. Finish - Pattern Controller: Baked enamel, black.

G. Finish - Tees: Baked enamel, color selected by Architect.

H. Slot Width: Per diffuser schedule.

I. Number of Slots: Per diffuser schedule.

J. Length: Per Diffuser schedule.

K. Accessories: Frame type as required for location to be installed.

L. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

2.4 REGISTERS AND GRILLES

A. Louver Face Return Grille:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Krueger.
    c. METALAIRE, Inc.
    d. Nailor Industries Inc.
    e. Price Industries.
    f. Titus.
    g. Tuttle & Bailey.

2. Material: Aluminum.
3. Finish: Powder coat, white
4. Face Blade Arrangement: Horizontal spaced ¾ inch apart.
5. Rear-Blade Arrangement: Vertical spaced ¾ inch apart.
6. Frame: 1-1/4 inches wide.
7. Mounting: Countersunk screw or Lay in, per the plans.

B. Louver Face Exhaust Registers shall be identical to louver face return grilles except provided with opposed blade damper.

2.5 LOUVER FACE DOUBLE DEFLECTION ADJUSTABLE FACE SUPPLY GRILLE:

A. Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. METALAIRE, Inc.
c. Nailor Industries Inc.
d. Price Industries (620D Basis of Design).
e. Titus.
f. Tuttle & Bailey

2. Material: Aluminum.
3. Finish: Powder coat, white.
4. Face Blade Arrangement: Adjustable, vertical, spaced 3/4 inch (19 mm) apart.
5. Rear-Blade Arrangement: Adjustable, horizontal spaced 3/4 inch (19 mm) apart.
6. Mounting: Countersunk screw.
7. Wall mounting or duct mounted as indicated on the plans.

2.6 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. All diffusers shall have a manual volume damper in the duct/tap serving the diffuser whether indicated on the plans or not. Face damper at diffusers shall not be used for balancing, the MVD shall be used.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 DIFFUSER SCHEDULE

A. Refer to schedule on the plans.

3.4 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 234100

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pleated panel filters – for AHUs and DHU

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

B. Comply with NFPA 90A and NFPA 90B.

2.2 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. 3M.
   b. AAF International.
   c. Camfil Farr.
   d. Flanders Corporation.

B. Filter Unit Class: UL 900

C. Media: Cotton and synthetic fibers coated with nonflammable adhesive.

D. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

E. Mounting Frames: Air Handling Unit factory filter module.

F. Capacities and Characteristics – MERV 8 filters:
1. Thickness or Depth: 2 inches unless otherwise indicated.
2. Maximum or Rated Face Velocity: 500 fpm.
3. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
4. Initial Resistance: 0.31-inch wg at 500 fpm.
5. Recommended Final Resistance: 1.0 inches wg.
6. MERV Rating: 8 when tested according to ASHRAE 52.2.

G. Capacities and Characteristics – MERV 13 filters:
1. Thickness or Depth: 4 inches unless otherwise indicated.
2. Maximum or Rated Face Velocity: 500 fpm.
3. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
4. Initial Resistance: 0.35-inch wg at 500 fpm.
5. Recommended Final Resistance: 1.0 inches wg.
6. MERV Rating: 13 when tested according to ASHRAE 52.2.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filters in position to prevent passage of unfiltered air.

B. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

C. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

D. Coordinate filter installations with duct and air-handling-unit installations.

3.2 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100

SECTION 235123

GAS VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Listed double-wall vents.

1.3 REQUIREMENTS

A. Boiler vent materials and the boiler, specified in Section 235216 – Condensing Boilers, are required to be provided by the same vendor to ensure coordination of boiler and vent requirements. Likewise, for the water heater specified in Section 223400 – Condensing Water heaters, the vent material for the water heater shall be by the same vendor as the water heater.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

B. Shop Drawings: For vents.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers.
4. Drawings shall include exact dimensions of vents as intended to be installed in the field.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Sample Warranty: For special warranty.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Heat-Fab, Inc.
2. Metal-Fab, Inc.
3. Selkirk Corporation.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

E. Lap joints in direction of flow.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 235123

SECTION 235216

CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes gas-fired, fire-tube (high mass) condensing boilers, trim, and accessories for generating hot water.

1.3 REQUIREMENTS

A. Boiler and boiler vent materials, specified in Section 235123 – Gas Vents, are required to be reviewed by the boiler manufacturer's representative to ensure coordination of boiler and vent requirements.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Submit cover letter stating that all requirements of the boiler have been reviewed against the design, with any discrepancies or modifications to the design to meet the manufacturer's requirements listed in the letter, and stated that they have been coordinated with the Contractor. All requirements of the boiler are to be coordinated with the Contractor prior to bidding such that all items including any required deviations from the design are accounted for in the Contractor's bid. Cover letter to include statement that vent and

combustion air intake routing, installation, size, material, termination, and any other requirements have been coordinated with the boiler manufacturer's requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Upon completion of the boiler installation the contractor shall arrange for the State of Alabama Boiler & Pressure Vessel Safety Division inspector to visit the job site to inspect the boiler installation. The contractor shall furnish a written report of his findings and comply with all comments.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:

a. Leakage and Materials: 10 years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

2.2 FIRE-TUBE HIGH MASS CONDENSING BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Lochinvar (Basis of Design)
2. Cleaverbrooks
3. RBI
4. Fulton

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

C. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.

D. Pressure Vessel: Carbon steel with welded heads and tube connections.

E. Burner: Natural gas, forced draft.

F. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel protective finish.
4. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

2.3 TRIM

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.4 ACCESSORIES

A. Condensate neutralization kit, one per boiler, sized per boiler manufacturer recommendations.

2.5 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Building Automation System Interface - BACnet: Factory install BACnet hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.6 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.

2.7 VENTING KITS

A. Vent: Refer to Section 235123 "Gas Vents."

B. Combustion air to be ducted from the outdoors to the boiler with single wall galvanized duct.

2.8 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s).

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Connect drain to condensate neutralization kit per manufacturers requirements and installation manual. If boiler vent has a drain, route through same condensate neutralization kit as the boiler.

I. Boiler Venting:
   1. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."
   2. Connect full size combustion air inlet to boiler connections.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

G. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify Architect 24 hours minimum in advance of test dates.
8. Document test results in a report and submit to Architect.

H. Upon completion of the boiler installation the contractor shall arrange for the State of Alabama Boiler & Pressure Vessel Safety Division inspector to visit the job site to inspect the boiler installation. The contractor shall furnish a written report of his findings and comply with all comments.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235216

SECTION 237313

MODULAR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Variable-air-volume, air-handling units, indoors and outdoors. AHUs have specific size limitations that must be met in order to bid. It is the Contractors' responsibility comply with limitations.

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.
2. Fan Belts: One set(s) for each air-handling unit fan
3. Fan Blank off plates: One blank off plate for each air-handling unit.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Comply with NFPA 70.

1.8 COORDINATION

A. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.9 DELIVERY, STORAGE, HANDLING

A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.

B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.

C. Store air-handling units in a clean dry place and protect them from weather and construction activities.

D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.

E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier
2. Daikin Applied (Basis of Design)
3. Trane.

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.
4. Factory Finish for Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. All units to have 2” thick double wall panels.

C. Provide interior lights in access sections and fan sections, 110V, powered by separate circuit than fan circuit.

D. Roof: Cross-broken and pitched with "C" caps over joints to provide watertight seal.

E. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type II.

2. Location and Application: Encased between outside and inside casing.

F. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:

a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.

4. Locations and Applications:

a. Fan Section: Doors and inspection and access panels.
b. Access Section: Doors.
c. Coil Section: Inspection and access panel.
d. Damper Section: Doors.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.

G. Condensate Drain Pans:

1. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
b. Depth: A minimum of 2 inches deep.

2. Formed sections.
3. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

a. Minimum Connection Size: NPS 1.

H. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick aluminum sheets; select metal compatible with casing.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd..
2) Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3) Fabric Service Temperature: Minus 40 to plus 200 deg F.

C. Plenum Fan Housings (“SWSI”): Steel frame and panel; fabricated without fan scroll and volute housing.

D. ECM Fans are not allowed.

E. Fan Arrays: Units to have blank off plates for fans. Insert blank off plates at each fan in lieu of backdraft dampers (due to added length of dampers).

F. Forward-Curved, Centrifugal Fan Wheels (“FC”): Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

G. Airfoil, Centrifugal Fan Wheels (“DWDI”): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

H. Fan Shaft Bearings:
1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.

I. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 15022 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Motors driven by VFD to be equipped with motor shaft grounding.

2.4 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with sections 234100.

2. Comply with NFPA 90A.
3. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
4. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

B. Filter Gage:

1. 3-1/2-inch-diameter, diaphragm-actuated dial in metal case.
2. Vent valves.
3. Black figures on white background.
4. Front recalibration adjustment.
5. 2 percent of full-scale accuracy.
6. Range: 0- to 2.0-inch wg.
7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch plastic tubing, and 2- or 3-way vent valves.

2.6 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.

2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

2.7 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.

1. Units Mounted on Concrete Bases:

a. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
b. Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.

c. Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.
d. Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.

B. Equipment Clearances and Access:

1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
2. Provide clearance and access required by governing codes and NFPA 70.
3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 PROTECTION DURING CONSTRUCTION

A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.

1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
2. Replace air-handling units with damage that in any way compromises the performance indicated.

3.4 DUCT CONNECTIONS

A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."

B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Provide duct transitions required to make field connections to air-handling units.

D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units

3.5 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.6 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
   2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Owner to Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

3.10 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.11 OPERATION DURING CONSTRUCTION

A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.

1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:

    a. Description of construction activities while units are operating.
    b. Operation:

        1) Beginning and ending calendar dates.
        2) List each day during week.
        3) List start and stop time and hours for each day.

    c. Startup procedures and shut-down procedures.
    d. Provisions for routine monitoring of unit operation.
    e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
    f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
    g. Record keeping.

2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least two years after the warranty indicated expires.
3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner. Refer to Section 3.10 Cleaning.

B. Filtration during Temporary Use:

1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.12 CLEANING

A. Cleaning Schedule:
1. Prior to testing, adjusting, and balancing of the air-handling unit and air-distribution systems, clean Unit Interior of air-handling units to remove foreign material and construction dirt and dust.
2. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before -Substantial Completion Final Inspection by the Engineer, Clean Unit Exterior, and reinspect the unit interior and re-clean if required.

B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.

1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
4. Clean light fixtures and control devices.

C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.

D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.

E. Acceptance: Following unit cleaning, submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237343

SECTION 238126

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes ductless wall mount split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

C. Delegated-Design Submittal: For fan supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   2. Wind- Restraint Details: Detail fabrication and attachment of wind restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts: One year(s) from date of Substantial Completion.
c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier Corporation; a unit of United Technologies Corp.
2. Daikin
3. LG.
4. Mitsubishi Electric & Electronics USA, Inc.
5. Trane.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer in the State of Alabama, to design mounting and restraints for equipment, including comprehensive engineering analysis.

1. Design equipment supports to comply with wind performance requirements.

B. Wind-Restraint Performance:

1. Basic Wind Speed: 120 mph.
2. Building Classification Category: III.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.3 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:

   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Condensate Drain Pans:

   a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

7. Air Filtration Section:

   a. General Requirements for Air Filtration Section:

      1) Comply with NFPA 90A.

B. Ceiling Cassette Ductless, Evaporator-Fan Components: Factory assembled and tested, include factory wiring, piping, electronic expansion valve, and controls.

1. Recessed Ceiling Cabinet: Enameled steel with removable panels on front and ends or high strength molded polymer, sound absorbing thermal insulation, adjustable four-way supply/return grille, washable polymer return air filter, outside air duct connection, supply air duct connections.
2. Refrigerant Coil: Copper tube with mechanically bonded aluminum fins, thermal-expansion valve, liquid and gas line thermisters, condensate pan, and condensate pump. Comply with ARI 210/240.
3. Fan: Direct drive, multi-speed, statically and dynamically balanced impeller, thermally protected motor.
4. Controls: Packaged networked control and diagnostics system, auto-restart function, time delays, return air thermister.
5. Performance: as scheduled on drawings.
6. Accessories:
   a. Remote temperature sensor kit.
   b. Integral condensate lift mechanism.

2.4 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

   a. Compressor Type: Scroll.
   b. Refrigerant Charge: R-410A.
   c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Low Ambient Wind Baffle Kit: Permits operation down to 10 deg F.
6. Mounting Base: Rubber isolators on roof mounted equipment rails.

2.5 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

D. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.4 OPERATION DURING CONSTRUCTION

A. Operation of units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.

1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:

    a. Description of construction activities while units are operating.
    b. Operation:

        1) Beginning and ending calendar dates.
        2) List each day during week.
        3) List start and stop time and hours for each day.

    c. Startup procedures and shut-down procedures.
    d. Provisions for routine monitoring of unit operation.
    e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
    f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
    g. Record keeping.

2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least two years after the warranty indicated expires.
3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner. Refer to Section 3.10 Cleaning.

B. Filtration during Temporary Use:
1. Protect units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
2. Do not operate units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
3. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.5 CLEANING

A. Cleaning Schedule:
1. Prior to testing, adjusting, and balancing of the air-handling unit and air-distribution systems, clean Unit Interior of air-handling units to remove foreign material and construction dirt and dust.
2. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before -Substantial Completion Final Inspection by the Engineer, Clean Unit Exterior, and reinspect the unit interior and re-clean if required.

B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.

1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
4. Clean light fixtures and control devices.

C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.

D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.

E. Acceptance: Following unit cleaning, submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 238126

SECTION 238127

BLOWER COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes blower coil indoor air handling units, horizontal, hung from structure above (AHU-OA).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each blower coil unit.
2. Fan Belts: One set(s) for each blower coil unit.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:
   a. For Parts: One year(s) from date of Substantial Completion.
   b. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 BLOWER-COIL UNITS

A. Manufacturers:

1. Carrier Corporation.
2. Trane
3. Daikin (Basis of Design)

B. Description: Indoor, horizontal or vertical as scheduled, factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995. Units to be double wall construction.

C. Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004.

D. Chassis: Galvanized steel where exposed to moisture, and removable access panels.

E. Cabinets: Heavy-Gauge double wall (foam filled) galvanized steel.

F. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated Cotton-Polyester Media: 13 MERV.

G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
1. Refer to schedules on the plans for coil rows for chilled water and hot water coils. Fewer coil rows than scheduled for chilled water coils will not be accepted.

H. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, ECM motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

I. Factory, Hydronic Piping Connections only (no piping package): ASTM B88, Type L (ASTM B88M, Type B) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

J. Controls:
1. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Div 25.

2.2 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Div 25.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to blower coil units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 OPERATION DURING CONSTRUCTION

A. Operation of units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.
1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
   a. Description of construction activities while units are operating.
   b. Operation:

1) Beginning and ending calendar dates.
2) List each day during week.
3) List start and stop time and hours for each day.

c. Startup procedures and shut-down procedures.
d. Provisions for routine monitoring of unit operation.
e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
g. Record keeping.

2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least two years after the warranty indicated expires.
3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner. Refer to Section 3.10 Cleaning.

B. Filtration during Temporary Use:
1. Protect units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
2. Do not operate units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
3. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.5 CLEANING

A. Cleaning Schedule:
1. Prior to testing, adjusting, and balancing of the air-handling unit and air-distribution systems, clean Unit Interior of air-handling units to remove foreign material and construction dirt and dust.
2. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before -Substantial Completion Final Inspection by the Engineer, Clean Unit Exterior, and reinspect the unit interior and re-clean if required.

B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
4. Clean light fixtures and control devices.

C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.

D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.

E. Acceptance: Following unit cleaning, submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.6 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 238127

SECTION 238219

FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hydronic Ductless fan coil units and accessories for the following types:
   a. Ceiling Cassette Style
   b. Wall Mount

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings – Horizontal units only: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which fan coil units will be attached.
3. Method of attaching hangers to building structure.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Maintenance schedules and repair part lists for motors, coils, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish 1 spare filters for each filter installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.9 WARRANTY

A. Manufacturer agrees to repair or replace components of units that fail in materials or workmanship within the warranty period of 1 year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 CEILING CASSETTE HYDRONIC FAN COIL UNITS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering ductless split system units which may be incorporated in the work include:

1. Carrier
2. Multiaqua (Basis of Design)
3. Polar Air

B. Fan Coil Unit Configurations:

1. Number of Heating Coils: Provide number of coils as required to meet the basis-of-design performance in the equipment schedules on the drawings.
2. Number of Cooling Coils: Provide number of coils as required to meet the basis-of-design performance in the equipment schedules on the drawings.

C. Coil Section Insulation: 1-inch-thick, coated glass fiber or foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Main and Auxiliary Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Vertical Unit Front Panels: Removable, steel, with integral stamped steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped or cast-aluminum discharge grilles.
3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan coil unit.
4. Steel recessing flanges for recessing fan coil units into ceiling or wall.

G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

1. MERV Rating: 7 when tested according to ASHRAE 52.2.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 15010 "Mechanical General Provisions."
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices and operational sequences are specified in Section 230923 "Control Systems – DDC Type."

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

L. Capacities and Characteristics:

1. Capacities and Characteristics listed in the equipment schedules on the drawings.

2.3 WALL MOUNT FAN COIL UNITS

A. Subject to compliance with the plans and specifications, provide equipment by one of the following:
1. Multiaqua
2. Carrier
3. Polar Air

B. Coil Section Insulation: Insulated complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Drain Pans: Polymer, fabricate pans and drain connections to comply with ASHRAE 62.1, with exterior of the drain pain insulated with closed cell insulation.

D. Cabinet: Polymer.

E. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
1. Washable Foam: 70 percent arrestance and MERV 3.

F. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 160 deg F. Include manual air vent and drain valve.

G. Fan and Motor Board: Removable.

1. Fan: Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board with thermal overload protection.
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

A. Control devices are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Electrical Connection: Factory wire motors and controls for a single electrical connection. Do not provide with a power cord intended for a wall plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers.

D. Install new filters in each fan coil unit immediately prior to Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 OPERATION DURING CONSTRUCTION

A. Operation of units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.
1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
    a. Description of construction activities while units are operating.
    b. Operation:
        1) Beginning and ending calendar dates.
        2) List each day during week.
        3) List start and stop time and hours for each day.
    c. Startup procedures and shut-down procedures.
    d. Provisions for routine monitoring of unit operation.
    e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
    f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
    g. Record keeping.
2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least two years after the warranty indicated expires.
3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner. Refer to Section 3.10 Cleaning.

B. Filtration during Temporary Use:
   1. Protect units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
   2. Do not operate units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
   3. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.6 CLEANING

A. Cleaning Schedule:
   1. Prior to testing, adjusting, and balancing of the air-handling unit and air-distribution systems, clean Unit Interior of air-handling units to remove foreign material and construction dirt and dust.
   2. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before -Substantial Completion Final Inspection by the Engineer, Clean Unit Exterior, and reinspect the unit interior and re-clean if required.

B. Unit Interior: Clean units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
   1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
   2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
   3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
   4. Clean light fixtures and control devices.

C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.

D. Cleaning Materials: Use cleaning materials and products recommended in writing by unit manufacturer.

E. Acceptance: Following unit cleaning, submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.7 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23821

SECTION 238239.19

WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes wall heaters with propeller fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berko; Marley Engineered Products.
2. Chromalox, Inc.
3. INDEECO.
4. Markel Products; TPI Corporation.
5. QMark; Marley Engineered Products.

2.2 DESCRIPTION

A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET

A. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.

B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

B. Motor: Permanently lubricated. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

A. Controls: Unit-mounted thermostat.

B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

Section 25 05 01 – Integrated Automation System General Requirements

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 02, Integrated Automation System Submittals

D. Section 25 05 03, Integrated Automation System Project Record Documents

E. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

F. Section 25 05 05, Integrated Automation System Training

G. Section 25 10 01, Integrated Automation System Networks

H. Section 25 10 02, Integrated Automation System Computer Systems, MMI

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Summary

A. This project requires the installation of a new Integrated Automation System (IAS) constructed using BACnet Field Level Devices. The IAS shall utilize a single Building Operations Server (BOS) based on point counts and available resources utilizing a web interface to all controlled devices.

B. The IAS Contractor will be required to perform the following:

1. Provide a new Integrated Automation System with Owner Furnish and Contractor Installed BACnet fully programmable and application specific DDC controllers for the equipment identified in the IAS drawings. Contractor shall select the Distech Controllers required for the project, providing quantities and model numbers for purchase by the Owner during the submittal process.

2. Provide Graphical User Interface Development for all of the devices identified in the submittals and illustrated within the IAS drawings.

3. Graphical User Interface development must match existing graphics, tool sets and features.

4. Furnish and install all items listed below in Section 1.3 General IAS Installation Scope of Work.

5. Review all of the design documents and specifications and report any discrepancies to the designer of record.

1.3 General IAS Installation Scope of Work

A. Contractor shall install a new IAS by furnishing and installing system to provide an open protocol, enterprise based, direct digital control, Integrated Automation System.

B. The new IAS components shall utilize network controllers, BACnet protocol, BTL certified devices, enterprise connectivity, electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform control sequences and functions specified.

C. The IAS will consist of monitoring and control of systems identified within the IAS drawings, which include integration of HVAC, power monitoring, lighting control and other systems as outlined.

D. The installation of Network Controllers and DDC control system devices for the HVAC equipment as illustrated on the IAS drawings and detailed in these specifications.

E. This includes all hardware, electrical installation, configuration, programming and commissioning coordination for the DDC system.

F. IAS Contractor shall implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.

G. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

H. Provide an Integrated System supplied by a company regularly engaged in the manufacturing and distribution of building automation systems. The IAS Manufacturer shall meet the following qualifications as a minimum:

1. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of building integration automation systems as specified herein, and must have been so for a minimum of three (5) years.

2. The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International.

I. The Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project.

1. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices.

2. Any and all required IDs and passwords for access to any component or software program shall be provided to the Owner.

J. Intelligent Equipment Integration. Network installation, software integration, network communication, and equipment configuration for all equipment types specified to be “Intelligent” shall be provided with a factory installed or equipment manufacturer provided communication card.

K. Refer to IAS drawings and coordinate with Mechanical and Electrical contractors to verify the correct communication options have been supplied.

L. The IAS Contractor shall coordinate with other trades to ensure that all equipment to be integrated is ordered with the proper communication cards and/or equipment required for proper integration.

M. All hardware installed for the project shall be constructed in a modular fashion to permit the next generation and support components to be installed in replace of or in parallel with existing components.

N. Where the project is an expansion of an existing system the Software utilized for the project shall be backward compatible with earlier releases, whenever possible.

O. Provision of all documentation called out in these specifications including, but not limited to, submittals, O&M manuals, commissioning submittals, CAD or Visio based as-built documentation, and training manuals.

P. Hardware, Software and Labor as detailed and described on the IAS drawings and the Division 25 specifications.

Q. DDC Controller programming and commissioning.

1. System point to point check out, verification and documentation.

R. Graphical User Interface Development.

1. The Contractor shall develop the graphics, tools, features, and network integration required and as defined in section 25 10 02.

S. The low voltage and communication raceway systems, wiring and terminations.

T. All requirements, products, and labor as identified in the Division 25 specifications and IAS Drawings.

1.4 Codes

A. Comply with Alabama State Building Code and the City of Tuscaloosa.

B. In all cases of conflict between the work of this Division, the Alabama State Building Code and the City of Tuscaloosa these details shall be brought to the attention of the Architect/Engineer at the time of bid proposal submission.

C. It is the Contractor's responsibility to identify any items of conflict or omission. These items shall be resolved prior to bid submission and included in the bid proposal price.

D. Where codes are listed herein, the applicable portions of the latest editions apply.

E. Drawings, specifications, codes and standards are minimum requirements. Where requirements differ, apply the more stringent.

F. Should any change in Drawings or Specifications be required to comply with regulations, the Contractor shall notify the Architect/Engineer prior to execution of the work and wait for direction from the Architect/Engineer.

1.5 Reference Standards

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship whose compliance with organizational standards/codes/specifications is regulated by an organization using its own listing or label as proof of compliance, furnish listing or label as required to ensure material complies with applicable referenced standard or specification.

D. All materials, installation and workmanship whose compliance with organizational standards/codes/specifications is not regulated by an organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.

1.6 Fees and Permits

A. Pay applicable fees and permits.

B. Pay royalties and fees required in connection with the use of patented devices and systems.

1.7 Coordination of Work with Existing Conditions

A. Examine and compare the Integrated Automation System (IAS) Specifications and Drawings with the Specifications and Drawings of the other trades and report any discrepancies between them to the Owner.

B. Obtain the Architect/Engineer's written instructions for changes necessary in the IAS work. Install and coordinate the IAS work in cooperation with the Commissioning Authority and the other trades installing interrelated work.

C. Before installation, make proper provisions to avoid interferences in a manner approved by the Architect/Engineer.

D. All changes required in the work of the Contractor, caused by noncompliance with the specifications, shall be made at the Contractor's expense.

E. Certain products, systems and interface devices may be provided by other trades.

F. Examine the Contract Documents to ascertain the requirements to install, wire, program, commission, and/or interface to these systems.

G. Particular attention must be paid towards the interface boards submitted by the various equipment providers.

H. It is the Contractor's responsibility to verify the submitted interfaces will integrate properly into the IAS. Report any discrepancies to the Architect/Engineer.

I. Carefully check space requirements with other trades to ensure that all material can be installed in the allotted spaces, including above finished suspended ceilings and under floors.

J. Transmit to other trades information required for work to be provided under their respective sections in ample time for installation.

K. Wherever work interconnects with work of other trades, coordinate with other trades and with the Owner's representative to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.

L. Identify all work items (valves, dampers, coils, etc.) in an accepted manner and notify the responsible trade to install access doors and panels at these locations.

M. Provide sleeves and conduit for passage of pipes, and wiring through structural masonry, concrete walls and floors, and elsewhere for the proper protection of the IAS work.

N. Coordinate, project and schedule work with other trades and with the Commissioning Authority in accordance with the construction sequence.

O. Adjust locations of panels, equipment, devices, and the like, to accommodate work and prevent interferences. Determine the exact route and location of each pipe, conduit or tubing prior to fabrication and installation.

1.8 Definitions

1. Adjustable (Adj): A characteristic of a control logic parameter such that it can be varied by the operator without downloading the program.

2. Advanced Application Controller (AAC): A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications.

3. Algorithm: A logical procedure for solving a recurring problem.

4. Analog: A continuously varying signal value (temperature, current, velocity, etc.).

5. Application Programming Tool: A vendor unique software tool used to create applications for programmable controllers. This software tool may also be used for system programming, controller commissioning, network management.

6. Application Protocol Data Unit (APDU): A unit of data specified in an application protocol and consisting of application protocol control information and possible application user data (ISO 9545).
7. Application Specific Controller (ASC): Control product that incorporates solid-state components based upon a microprocessor to perform multiple control loops or functions as part of a specific application.
    a. ASC shall conform to the BACnet/BTL certification and integration standards
8. BACnet or BACnet Standard: BACnet communication requirements as defined by ASHRAE/ANSI 135 and all current addenda and annexes.
9. BACnet Interoperability Building Blocks (BIBB): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task.
    a. BIBBS are combined to build the BACnet functional requirements for a device in a Specification.
10. BACnet over Internet Protocol (BACnet/IP): BACnet communication requirements as defined by ASHRAE/ANSI 135 and all current addenda and annexes utilizing Internet Protocol addressing as described in IETF publication RFC 791.
11. BACnet over Master Slave Token Passing Protocol (BACnet MS/TP or MS/TP): BACnet communication requirements as defined by ASHRAE/ANSI 135 and all current addenda and annexes utilizing a master slave token passing network scheme utilizing RS-485 communications.
12. Bandwidth Utilization: The average utilization of the network capacity. Generally speaking the amount of present network traffic as it relates to the maximum amount of traffic for which a network can support.
13. Binary: A two-state system where a high signal level represents an “on” condition and an “off” condition is represented by a low signal level.
14. Binding: In the general sense, binding refers to the associations or mappings of the sources network variables or objects and their intended or required destinations.
    a. The concept of associating an output network variable from one device to the input network variable of a second (third, fourth, etc.) device.
15. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net or domain of the same physical communication media.
16. Building Operations Server (BOS): A device that incorporates 1 or more network service host APIs to perform localized network management and network access services over a group of channel(s).
    a. Supervises groups of intelligent devices and Control Units to perform a global sequence of operation (ex: fire and life safety control).
    b. Can be configured to serve as a SCADA client on the IAS, Tier 1, and Local Area Network.
    c. Provides integration to Enterprise level systems and other protocols.
    d. The BOS serves the following key functions:
        1) Time Schedules: Time schedule algorithms shall reside in the BOS. Occupancy/energize commands shall be broadcast to the equipment level controllers in the number required by the sequence of control.
        2) Trend Data Storage: The BOS shall collect data from the equipment level controls at specified intervals and store the data for periodic uploading to the server. Polling communication techniques are acceptable for data collection by the network controller.

3) Alarm Generation: The BOS shall receive binary alarm variables from the building level controllers and transmit this data to the alarm handling software module within the server and operator work stations. Receipt of alarm data from the building level controls shall be based on broadcasting from the building level controls and not based on polling by the Network Controller.

4) Interlock and control: The network controller shall perform sequence of operation logic and control where appropriate.

5) Control Systems Server:

a) Maintains system configuration and programming database.

b) Holds the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers.

c) Acts as a control information server to non-control system-based programs. All allows secure multiple-access to the control information.

17. Bus Topology: A term used to describe the sequential connection of devices on a DLN segment. The communication cable runs from device to device with no tees or stubs from the main communication cable to a device.

18. Change of Value (COV): An event that occurs when a measured or calculated analog value changes by a predefined amount.

19. Channel: A DLN network consisting of two segments connected by a physical layer repeater or router configured as a repeater.

    a. Each segment can support a theoretical limit of 64 connections.

20. Client: A device that is the requestor of services from a server.

    a. A client device makes requests of and receives responses from a server device.

21. Commissioning: A process of ensuring that systems are installed, functionally tested and capable of being operated and maintained to perform in conformity with design intent.

    a. Control System commissioning requires a point to point check out and the detail documentation of each parameter.

    b. Commissioning includes a complete functional test of the sequence of operation for each piece of equipment.

22. Continuous Monitoring: A sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).

23. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including HVAC control, switchgear, uninterruptible power supplies, lighting, security, interlocks, thermostats, EP and IP switches and like devices.

    a. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operation.

24. Controller or Control Unit (CU): Intelligent stand-alone control panel.

    a. Controller is a generic reference and shall include Building Operations Servers (BOS), Equipment Controllers (EC) and Terminal Controllers (TC) as appropriate.

25. Control Systems Server (CSS): A computer that maintains the systems configuration and programming database.
    a. This may double as an operator workstation for smaller systems.
26. Deadband: A temperature or lighting range over which no heating, cooling, or lighting energy is supplied as opposed to single point changeover or overlap.
27. Device instance: A number that uniquely identifies a device on the Device Level Network (DLN).
28. Direct Digital Control (DDC): Microprocessor-based control including Analog/Digital conversion and program logic.
29. Discrete: Binary or digital state.
30. Distributed Control: A system whereby control processing is decentralized and independent of a central computer.
31. Diagnostic Program: Machine-executable instructions used to detect and isolate system and component malfunctions.
32. DLN: Device Level Network – The local control system network that incorporates servers, control devices and software applications.
33. EEPROM: Electrically Erasable Programmable Read-Only Memory – non-volatile, user modifiable, read-only memory that can be erased and reprogrammed repeatedly through the application of a higher than normal electrical voltage.
34. FAC LAN: Facility Local Area Network.
35. Functional Profile: A collection of variables required to define key parameters for a standard application.
    a. For the HVAC industry, this includes applications like VAV terminal units, fan coil units, etc.
36. Gateway: A device, which contains two or more dissimilar networks/protocols, permitting information exchange between dissimilar systems.
37. Graphical User Interface (GUI): A Man Machine Interface device (PC, laptop or dumb display terminal) which incorporates web browsing for remote network client services as a thin client machine.
    a. The Graphical User Interfacing allows the operator to manage, command, monitor, configure and program the system.
    b. It shall function as the point of interface for all control and monitoring functions as well as all data logs, trends, and alarming.
38. Hand Held Device (HHD): Manufacturer's microprocessor based device for direct connection to a Controller.
39. HTTP: Hypertext Transfer Protocol: the set of rules for exchanging data files (text, graphic images, sound, video and other multimedia files) over the Internet.
40. Integrated Automation System (IAS). The complete facility control system comprised of mechanical system automation, security control, lighting control, automatic temperature control, etc., as defined in the contract documents.
    a. The IAS is comprised of a tiered network structure.
    b. The primary tier uses Ethernet, TCP/IP protocol in a 10/100/1000 Base T wiring configuration.

1) The IAS also includes interface panels, bridges, network controllers, LAN wiring, raceways, etc.

2) All system data shall be made available to the Owner's Wide Area Network for building management.

3) The functionality of the system will allow building engineers the ability to view and modify the facility from any point on the Owner's WAN.

c. The second tier uses BACnet for distributed control processing.

41. Interface Panel: A device that contains an I/O software driver to translate data from a particular format to that conforming to BACnet standards. Also see Gateway.

42. IT LAN: Reference to the facility's Information Technology network, used for normal business-related e-mail and Internet communication.

43. LAN: Local Area Network – a group of computers and/or associated devices which share a common communications line and typically share the resources of a single processor or server within a small geographic area.

44. LAN Interface Device (LANID): Device or function used to facilitate communication and sharing of data throughout the IAS.

45. MAC address: The MAC (Media Address Control) address uniquely identifies a device on its MS/TP network.

46. Master Devices: Master devices can initiate requests for data but require more processing and memory capacity than slave devices.

47. Master-Slave/Token Passing (MS/TP) network segment: An electrically separate section of a network. An MS/TP network segment contains no more than 32 full Unit Loads. Repeaters connect the segments of an MS/TP network.

48. Maximum Send Time Parameter: A parameter used to ensure the periodic update of network data. If a time period equal to the value of this parameter has expired without a broadcast of the variable, a re-broadcast of the current value shall be executed. See also minimum send time parameter definitions.

49. Minimum Send Time Parameter: A parameter used to control unnecessary broadcasting of data onto the network. A broadcast of an updated value shall not occur unless a time period equal to the value of this parameter has expired. The expiration of the time period does not mandate a re-broadcast. See also maximum send time parameter definitions.

50. Network: A system of distributed control units and intelligent devices that are linked together on a communications bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.

51. Node: A device connected to a communications network.

52. Open Database Connectivity (ODBC): An open standard application-programming interface (API) for accessing a database. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.

53. Operator Interface (OI): A device used by the operator to manage the EMCS including OWSs, POTs, and HHDs.

54. Operating System (OS): Software which controls the execution of computer programs and which provides scheduling, debugging, input/output controls, accounting, compilation, storage assignment, data management, and related services.
55. Operator Workstation (OWS): A Man Machine Interface device (PC, laptop or display terminal) which incorporates web browsing for remote network client services.
56. Peripheral: Input/Output equipment used to communicate to and from the computer and make hard copies of system outputs and electronic files. Peripherals include CRT, printer, hard drives, disk drives, modems, etc.
57. Point: Analog or discrete instrument with addressable database values.
58. Point-to-Point (PTP): Serial communication as defined in the BACnet standard.
59. Polling: The concept of a control device requesting a network variable from a second control device at a specified interval.
60. Polling communication is typically used to populate dynamic data on an active graphic page and for temporary or short term trending of data where the trend data is not stored at the controller level.
61. Portable Operators Terminal (POT): Laptop PC used both for direct connection to a controller and for remote dial up connection.
62. Protocol Implementation Conformance Statement (PICS): A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.
63. Repeater: A physical device used to connect two segments while amplifying, conditioning, or strengthening the signal. A Repeater does not provide any routing or filtering of network traffic.
64. Router: A device which routes or forwards messages destined for a node on another subnet or domain of the DLN. The device controls message traffic based on node address and priority. Routers also serve as communication interfaces between power line, twisted pair and RF media.
65. RS-232: EIA/TIA-232 Standard
66. RS-485: EIA/TIA-485 Standard
67. Secure Socket Layer (SSL): A commonly used protocol for managing the security of messages transmission on the Internet.
68. Server: A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
69. Simple Object Access Protocol (SOAP): A method for a program running in one type of operating system to communicate with a program on the same or different type of operating system by using the World Wide Web's Hyper Text Transfer Protocol (HTTP) and its Extensible Markup Language (XML) as the mechanisms for information exchange.
70. Slave Devices: Slave devices cannot initiate requests for data; they can reply only to messages from other devices. They are best suited for simple, low-cost functions.
71. Smart Device: A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected.
72. Solenoid: Electric two-position actuator.
73. Structured Query Language (SQL): A standard interactive and programming language for retrieving information from and for updating a database via an organized series of queries.

74. Stand-Alone Controller: A stand-alone controller has provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air handling unit, chiller or boiler. The controller shall also have embedded in it all of the control logic that associated the physical inputs to the physical outputs. A stand-alone controller may rely on other networked devices for time schedule inputs and trend data storage.
75. Supervisory Control and Data Acquisition (SCADA) Node: An MMI incorporating a graphical object-oriented user interface software application which provides supervisory control and data acquisition from a high level processing personnel computer.
76. Supervisory Logic: The concept of gathering performance data from multiple terminal units to determine if a specific condition exists within the family of terminal devices.
77. Terminator: An electric component that consists of a resistive and capacitive circuit specifically designed to enhance the quality of communication on a segment. On a bus topology, terminators are connected to both ends of a segment. On MS/TP and free topology network segments a single terminator is required. The terminator is placed at the end-of-line for the MS/TP network segment.
78. Trend Log: A trend log is a collection of samples from a specified variable that are stored within a device on the IAS Network. This data may be periodically sent up to or requested by a Network Controller or an Operator Workstation for the purpose of report generation.
79. UUKL Listing: Underwriter's Laboratory UL 864 Listed, 9th Edition, UUKL Smoke Control System.
80. WAN: Wide Area Network - Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser.
81. XML (Extensible Markup Language): A specification developed by the World Wide Web Consortium. XML is a pared-down version of SGML, designed especially for Web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data between applications and between organizations.

1.9 Abbreviations

1.	AHU	Air Handling Unit
2.	AI	Analog Input
3.	ANSI	American National Standards Institute
4.	AO	Analog Output
5.	Approx.	Approximately
6.	ASC	Application Specific Controller
7.	ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
8.	ASPE	American Society of Plumbing Engineers
9.	ASME	American Society of Mechanical Engineers
10.	ASTM	American Society for Testing and Materials
11.	ATC	Automatic Temperature Control System
12.	AWG	American Wire Gauge (Standard)
13.	EMCS	Building Automation System

14. BMS Building Management System
15. BOS Building Operations Server
16. CAD Computer Aided Design
17. Contr. Contractor
18. COS Change of State
19. CPU Central Processing Unit
20. CRAC Computer Room Air Conditioning
21. CRT Cathode Ray Tube
22. DALI Digital Addressable Lighting Interface
23. DDC Direct Digital Controls
24. Deg. F or °F Degree Fahrenheit
25. DI Discrete or Digital Input
26. Dia. or diam. Diameter
27. DMA Direct Memory Access
28. DO Discrete or Digital Output
29. Dwgs. Drawings
30. EP Electric-pneumatic
31. EMCS Energy Management Control System
32. FAC LAN Facility Local Area Network
33. FPB Fan powered (VAV) box
34. FPM Feet per minute
35. FACP Fire Alarm Control Panel
36. FCC Fire Command Center
37. FCIP Firefighters' Control and Indicating Panel
38. FMS Facility Management System
39. Galv. Galvanized
40. GUI Graphical User Interface
41. HVAC Heating Ventilating and Air Conditioning
42. IAS Integrated Automation System
43. I/O Input / Output
44. ISA Intelligent Sensor or Actuator
45. LCU Local Control Unit
46. NCU Network Controller Unit
47. NSS Network Services Server

48. NSI Network Services Interface
49. Mfr. Manufacturer
50. Max. Maximum
51. Min. Minimum or Minute
52. MMI Man-Machine Interface
53. MSCP Mass Storage Control Protocol
54. MSI Master System Integrator
55. NCP Network Control Panel
56. NEC National Electrical Code
57. NI Network Integrator
58. NIC Not in Contract
59. NFPA National Fire Protection Association
60. O.C. On Center
61. O.D. Outside Diameter
62. OS Operating System
63. PE Pneumatic-electric
64. Per According to, in accordance with
65. PRV Pressure Reducing Valve
66. Provide Furnish and install
67. RAM Random Access Memory
68. ROM Read Only Memory
69. RTD Resistance Temperature Device
70. SCADA Supervisory Control and Data Acquisition System
71. SI Systems Integrator
72. SNVT Standard Network Variable Type
73. TCP/IP Transmission Control Protocol / Internet Protocol
74. TCU Terminal Control Unit
75. THHN Thermoplastic High Heat Resistant Nylon Coated-Cable coating
76. TP Twisted Pair
77. UBC Uniform Building Code
78. UL Underwriters' Laboratory
79. UMC Uniform Mechanical Code
80. UML Unified Modeling Language
81. UPS Uninterruptible Power Supply

82.	VAV	Variable Air Volume
83.	VCS	Voice Communication System
84.	VFD	Variable Frequency Drive
85.	XML	Extensible Markup Language

1.10 Quality Assurance

A. All new building automation system products on this project shall be provided by a firm that is a registered ISO 9001:2000 manufacturer at time of bid.

B. The IAS shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The Systems Integrator shall be Factory Authorized in good standing with the Manufacturer. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

C. Upon request, installer shall present records of successful completion of factory training courses including course outlines.

D. Upon request the installer shall provide a letter from the manufacturer that they are Factory Authorized in good standing.

1. All microprocessor-based control products used shall conform to BTL Certified Standards.

E. For equipment types that certified devices do not exist, another interface to that equipment must be provided upon approval of the Architect/Engineer.

F. It is the Contractor's responsibility to verify that the equipment manufacturers provide the appropriate interface boards as defined in these specifications and design drawings.

G. The contractor shall provide hardware and software components of the same manufacturer wherever possible.

H. The contractor shall use standard off-the-shelf components and/or products whenever possible. Custom products shall not be used unless approved prior to the installation.

I. Materials and equipment shall be catalogued products and shall be manufacturer's latest standard design that complies with the specification requirements. Where multiple units of the same type or function are required for this project, these units shall be products of a single manufacturer.

J. All equipment shall be manufactured, installed and tested to comply with the acceptance testing requirements specified herein.

K. Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of one (1) year since date of final completion in at least ten (10) installations of comparative size and complexity.

1. Submittals shall document this requirement with references.

L. The IAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.

M. The IAS components, used to implement smoke control strategies, shall be UUKL listed.

1.11 IAS Installer's Qualifications

A. IAS Installer to:

1. Have local office within 100 miles of project for at least 5 years, staffed by trained personnel capable of providing instruction, routine maintenance and emergency service on systems.
2. Provide record of successful installations of similar size, performed by Systems Integrator submitting the tender, showing successful experience with similar computer-based systems.
3. Have in-house staff with expertise in pneumatic controls where applicable.
4. Provide Profiles for each employee who will be involved in this project.

1.12 System Architecture

A. The system provided shall incorporate hardware and software resources sufficient to meet the functional requirements of these Specifications.

B. The DLN shall be based on industry standard open platforms as specified herein and utilize commonly available operation, management and application software.

C. All software packages shall be licensed to the Owner to allow unrestricted maintenance and operation of the IAS.

D. Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications, including but not limited to:

1. Network Operating software
2. Device Drivers and Plug-ins
3. File Server Software
4. Graphical User Interface (GUI) and Utility software
5. Network Management, Configuration, Controller/System Programming and Utility software
6. Original electronic media and licenses for all software packages utilized to implement the IAS

E. The system architecture for the campus-wide IAS consists of an Ethernet-based Local Area Network (LAN) with existing Enterprise Level Server that supports multiple Building Operation Server integration. The following indicates a functional description of the existing campus-wide structure:

1. Facility Local Area Network (FAC LAN): The FAC LAN shall be an Ethernet-based, 10/100/1000 Ethernet LAN.
2. The FAC LAN serves as the backbone for the BOSs communications path to Enterprise Level Server and to Peer Building Operations Servers.
3. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 6 cable with switches and routers that support 1000 base-T gigabit Ethernet throughput.
4. The FAC LAN shall be installed in accordance with IEEE 802.3, TIA/EIA 568-B and TIA/EIA 569-A.
5. The FAC LAN shall be provided by others.

F. The system architecture for the building-level IAS shall consist of an Ethernet-based Device Level Network (DLN), connecting Building Operations Servers (BOS) to Equipment Controllers (EC) and Terminal Controllers (TC). The following indicates a functional description of the building level structure. The contractor shall utilize these components of the IAS for the scope of this project:

1. Device Level Network (DLN): The DLN shall be an Ethernet-based, 10/100/1000 Ethernet LAN.
2. The DLN serves as the backbone for the BOSs communications path to ECs and TCs.

3. DLN shall be IEEE 802.3 Ethernet over Fiber or Category 6 cable with switches and routers that support 1000 base-T gigabit Ethernet throughput.
4. The DLN shall be installed in accordance with IEEE 802.3, TIA/EIA 568-B and TIA/EIA 569-A.
5. The DLN shall be provided by the contractor.

G. Dynamic Data Access: Data throughout any level of the LAN or DLN shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely as defined in the point list schedules.

H. Remote Data Access: The system shall support Internet Browser-based remote access to the building data.

I. Browser-based access: A remote/local user using a standard browser will be able access all control system facilities and graphics via the LAN or direct connection, with proper username and password.

1. Only Internet browser-based user interfaces (HTML5, Java, XML, CCS3 JAVA Script, etc.) are acceptable.

J. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser.

K. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface.

1. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

L. The communication speed between the controllers, DLN interface devices, BOS and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with Shop Drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements:

1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
3. 20 seconds between a Level 3 to 5 alarm occurrence and enunciation at operator workstation.
4. 10 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controller.
5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least ten (10) points.

M. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, FireFox™ or Chrome™.

N. The Equipment Controllers (EC) and Terminal Controllers (TC) shall monitor, control, and provide the field interface for all points specified. Each EC and TC shall be capable of performing all specified energy management functions and all DDC functions, independent of other ECs and TCs and operator interface devices.

1. The ECs and TCs used to implement smoke control strategies shall be UUKL listed.

O. User tools for DLN management shall be provided and licensed to the Owner and shall allow unrestricted configuring, updating, maintaining and expanding of all devices, configurations and settings.

P. All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication.

1.13 Delivery, Storage and Handling

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.14 Warranty

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.

2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.

4. In the last month of the Warranty Period, all System software and controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period. Provide the owner with a 5-year option for software upgrade maintenance services

5. Warranty Period: One year from date of Substantial Completion.

1.15 Owner Furnished Equipment

A. Owner furnished controls equipment shall include the following:

1. Building Operations Server with Operating System and UPS.

2. Distech Equipment Controllers. Type require and quantities to be selected by the Controls Contractor and indicated on the submittals for Owner purchase.

B. Owner furnished network equipment shall include the following. Quantity of each to be identified by the Controls Contractor and indicated on the submittals for Owner purchase:

1. Optigo ACC-PS-48V300W Power Supplies

2. (1) Optigo ONS-NC-600 Network Controller

3. Optigo ONC-CD0840GP Aggregation/Operations Switches

C. Application software and programming for all owner furnished controllers shall be provided by contractor.

PART 2 - PRODUCTS

2.1 Manufacturers

A. Furnish building automation system components supplied by a company regularly engaged in the manufacturing and distribution of building automation systems. The BAS Manufacturer shall meet the following qualifications as a minimum:

1. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of building automation systems as specified herein, and must have been so for a minimum of five (5) years.

B. Product Manufacturers

1. Distech Controls

C. Materials and Equipment

1. Materials shall be new, the best of their respective kinds without imperfections or blemishes, and shall not be damaged in any way.

2. Used equipment shall not be used in any way for the permanent installation except where Drawings or Specifications specifically allow existing materials to remain in place.

D. Uniformity

1. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

2.2 IAS Integrators/Installers

A. Provide a fully functioning building automation system as defined in this specification and related documents. The system integrator shall meet the following qualifications as a minimum.

1. The system integrator of the hardware and software components must be primarily engaged in the installation/integration building automation systems as specified herein, and must have been so for a minimum of five (5) years.

2. The system integration firm must be factory trained and certified by the product manufacturer.

3. Approved System Integrators

a. Alabama Controls inc. DBA Albireo Energy LLC

b. CSUSA Mid-South Controls

c. Engineered Cooling Services

PART 3 - EXECUTION

3.1 Preparation

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

B. These specifications call out certain duties of the Contractor and any subcontractor(s). They are not intended as a material list of all items required by the Contract.

3.2 Installation

A. General Installation Requirements:

1. Utilize licensed electricians for all new and retrofitted electrical distribution systems. Installations of high and low voltage systems shall be in accordance with all building code requirements. Obtain electrical permits, if required by local authorities.
2. Provide related items and work indicated on the IAS Drawings and items and work called for in this Division of the Specifications.
3. This includes all incidentals, equipment, appliances, services, hoisting, scaffolding, supports, tools, supervision, labor, consumable items, fees, licenses, etc., necessary to provide complete systems.
4. Perform start up, configuration, programming and commissioning coordination on each control product and system to provide fully operable systems in accordance with the specified functional performance.
5. Comply with Federal, State, Municipal and other applicable codes and ordinances. If any conflict arises between these Specification and Drawings, and codes and ordinances, immediately notify the Owner's Representatives. Do not deviate from the Drawings and Specifications nor install any work which may be in conflict with codes and ordinances until the conflict is resolved and the solution accepted by the Owner.
6. The IAS Drawings show the general arrangement of the respective systems.
7. Follow these Drawings as closely as actual building construction and the work of other trades will permit.
8. Provide devices, fittings, sensors, controllers, wiring and accessories, which may be required but are not shown on the Drawings or specified herein.
9. The Contractor shall be responsible for achieving the sequence of operations and intent of the system design.
10. Investigate conditions affecting the work and arrange the work accordingly. Provide modifications and accessories as may be required to meet such conditions.
11. All installation shall be in accordance with manufacturer's published recommendations.
12. Limit LAN and DLN cable lengths to no longer than 80% of the longest dimension published by the manufacturer of the cable between the most remote network nodes.
13. Install products level, plumb, parallel, and perpendicular with building construction.
14. Support products, tubing, piping wiring and raceways.
15. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
16. Firestop penetrations made in fire-rated assemblies.
17. Fastening Hardware:
    a. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
    b. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
    c. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

18. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.3 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.

2. Equipment to Be Connected: Refer to Drawings.

a. It is the contractor's responsibility to coordinate during submittal with equipment to be provided and indicated require connections on the Controls Submittal Drawings.

3.5 Controller Quantity and Location

A. Equipment Controllers (EC) and Terminal Controllers (TC) are referenced to indication allocation of control points to each controller and controller location.

B. Where an EC or TC is referenced, a minimum of one control device, and additional devices as required, shall be provided to meet the requirements of this Specification. Contractor shall provide power to devices from an acceptable power source. Contractor is responsible for ensuring that devices are located to not interfere with other requirements of the Project and maintain adequate clearance for maintenance access.

C. Contractor shall locate ECs and TCs as referenced on plans. It is the Contractor's responsibility to identify enough controllers for Owner purchase to ensure a completely functioning system, according to the point list and sequence of operations.

3.6 Network Management Functional Requirements

A. The Contractor shall coordinate the setup and configuration of the IAS local area network hardware to permit the functional requirements of the IAS herein specified. The setup shall include as a minimum, the following network management procedures:

1. Automatic backup of the DDC System database to appropriate media.
2. Program, load and debug all software installations.
3. Network user auditing routine.

3.7 Surge Protection

A. Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all controllers and field devices. All equipment shall be capable of handling voltage variations 10 percent above or below measured nominal value, with no effect on hardware, software, communications, and data storage.

3.8 Control Power Source and Supply

A. IAS Contractor shall extend all power source wiring required for operation of all equipment and devices provided under Division 23 and 25 and the Drawings.

B. General requirements for obtaining power include the following:

1. In the case where additional power is required, obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 480V or 600V source, obtain power from the electrically most proximate 120v source fed from a common origin.
2. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source of power as the equipment. If the equipment's control transformer is large enough and is the correct voltage to supply the controls, it may be used. If the equipment's control transformer is not large enough or of the correct voltage to supply the controls, or is too noisy for reliable control, provide a separate transformer.
3. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, and/or interruptible), the controller shall be powered by the highest level of reliability served.

3.9 Product Delivery, Storage, Handling, Protection and Cleaning

A. All products and materials shall be new, clean, and free of defects, damage and corrosion.

B. Ship and store products and materials in a manner which will protect them from damage, weather, and entry of debris. Do not install damaged items - take immediate steps to obtain replacement or repair.

C. The Contractor shall provide adequate means for and shall fully protect all finish parts of the materials and equipment against damage from any cause during the progress of the work until final acceptance. All materials and equipment in storage and during construction shall be covered in such a manner that no finished surfaces will be damaged or marred, and all moving parts shall be kept clean and dry. The Contractor is responsible for providing storage of materials and equipment.

D. Equipment and accessories shall be thoroughly cleaned of cement, plaster, and other materials; grease and oil spots shall be removed with cleaning solvent and surfaces carefully wiped.

E. Panels housing electronic controllers shall be constructed so that the panel and associated wiring may be installed independent of the installation of the electronics. The installation of electronics shall be coordinated with other trades and construction schedules to avoid damage.

3.10 Identification

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.

    a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Tag shall consist of white lettering on black background.

3. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.

4. Tag shall be fastened with drive pins.

5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Division 26 "Identification for Electrical Systems."

2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "Building Controls," using an engraved phenolic tag.

End of Section 25 05 01

Section 25 05 02 – Integrated Automation System Submittals

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 03, Integrated Automation System Project Record Documents

E. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

F. Section 25 05 05, Integrated Automation System Training

G. Section 25 10 01, Integrated Automation System Networks

H. Section 25 10 02, Integrated Automation System Computer Systems, MMI

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Submittals

A. General: See Division 1 specifications and 230100 Mechanical General Provisions for general submittal requirements.

B. Functional Intent: Throughout the Contract Documents, detailed requirements are specified, some of which indicate a means, method or configuration acceptable to meet that requirement.

1. Contractor may submit products that utilize alternate means, methods, and configurations that meet the functional intent - these will only be allowed with prior approval.

C. Electronic Submittals: While all requirements for hard copy submittal apply, IAS control submittals and operation and maintenance (O&M) information shall also be provided in electronic format as follows:

1. Drawings and Diagrams: Shop Drawings shall be provided on electronic media in Visio file format.

2. Other Submittals: All other submittals shall be provided in Adobe Document Format

3. Qualifications: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate items.

a. Submit a list of no less than five similar projects, which utilize the Enterprise connectivity to provide an Integrated Automation System that consists of web-browser control and monitoring of the proposed field level devices.

b. These projects must be on-line and functional such that representatives from the Owner can observe the Integrated Automation System and Interface in full operation. Include proper references and contact numbers of these reference projects.

c. Submit validation which indicates the successful completion of the required certification course(s).

d. Submit resumes of installing staff indicating passing certificates for training on the line of controls to be installed as part of this project. Also include prior Instrumentation and Control experience.

e. Submit an organizational diagram indicating the key technical staff proposed for the project including Project Manager, Application Engineer, Programmers, Superintendent, Electrical Foreman, Electricians, and Technicians etc.

f. Provide staff quantities to be assigned to the project. Provide contact information for Managers, Programmers, and Lead Technicians upon acceptance of bid.

g. Submit a record of the number of personal employed by the System Integrator.

h. This submittal shall clearly indicate the number of managers, technicians, electricians, and programmers certified in the line of DDC controls represented and certified in graphical user interface development and system network management.

i. Also indicate the number of staff that will be assigned to this project.

j. Provide certifications of all employed personal trained and certified by an Enterprise Network Infrastructure manufacturer for GUI integration and development.

k. Identify the number of integrators to be assigned to this project.

l. The Contractor shall indicate the duration, in which the company has represented the line of controls proposed for this project.

m. The Contractor shall also disclose all previous manufactures that have been or currently are represented over the last seven (7) years.

n. GUI development software

1) Provide screen captures of graphical user interfaces developed by the Contractor on previous projects. These screen shots shall represent work performed by the contractor and not of the company from the line of controls which the Contractor represents. Provide client contact information for the Owner to validate.

4. Product Data: Submit manufacturer's technical product data for each Network Control Unit, control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.

5. Products: Submit for acceptance a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom the Contractor proposes to employ.

a. Provide a list of devices in schedule form on 8½ x 11 sheets. The schedule shall be organized by columns to define all new devices to be installed as part of the EMCS system including the location, system served, controlling unit, model number, performance data, size, range, accuracy, span, operating pressure, etc.

b. Submit documentation indicating BTL compliance and include Protocol Implementation Conformance (PIC) Statements. All PIC statements, product literature, and standard configuration parameters shall be compiled and submitted on electronic media for the following.

1) Building Operations Server (BOS) – Software Only

2) Intelligent Sensors and Actuators

3) Interface Panels

4) Network Management Equipment (Routers, Protocol Analyzers, etc.)

c. Submit detailed cut sheets indicating the features, accessories and sub-assemblies of the following, or similar as required:

1) All ancillary devices including temperature sensors, flow sensors, and the like, including thermal wells where necessary

2) Pressure gauges, thermometers and indicating devices where shown on the drawings

3) Transformers required for control devices

4) Relays

5) Electrical enclosures and back-plates

6) Wire for DLN, and all sensors and actuators

7) Hub(s), Switches, and Routers

8) DLN Repeaters

9) Gateway and interface devices

10) Network Management Utility Software

11) Application Programming Tools/Software (DDC controller programming software)

12) Interface devices

13) Web based configuration and programming for control devices

6. Shop Drawings: For each control system, including a complete drawing for each controller identified in the IAS drawings with all point descriptors, addresses and point names indicated. Include mounting details and power supplies. Shop Drawings shall contain the following information:

7. System Architecture and System Layout:

a. One-line diagram indicating how the new network controller units will integrate with the IAS field level devices.

b. Provide floor plans locating the BOS, ECs and TCs, workstations, servers, DLN interface devices, etc.

c. Include all DLN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, MAC address, device instance, drawing reference number, and controller type for each device.

d. Indicate media, protocol and type of each DLN segment.

e. All controllers, sensors located in finished areas, I/O devices installed in mechanical systems, repeaters, end-of-line resistors, other IAS related components, sensors and actuators, etc. shall be located on the floor plans.

f. Wiring routing and as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately to reflect actual installed conditions.

g. Schematic flow diagram of each air system showing fans, coils, dampers, valves, and control devices. Include written description of sequence of operation.

h. All physical and logical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses as identified in the point list schedule.

i. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number).

j. Label each control device with setting or adjustable range of control.

k. Label each input and output with the appropriate range.

l. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.

m. With each schematic, provide valve and actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers

n. Provide detailed schematics for interface connections including installation and commissioning specifics. Include detailed terminal interconnect diagrams for connecting to equipment manufacture's integral communications boards.

o. Indicate all required electrical wiring.

p. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified.

q. Provide panel termination details on separate Drawings. Ladder diagrams shall appear on system schematic.

r. Clearly differentiate between portions of wiring that exists, factory-installed and portions to be field-installed.

s. Provide details for wiring color code assignment.

t. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.

u. Sheets shall be consecutively numbered.

v. Each sheet shall have a title indicating the type of information included and the system type controlled.

w. Table of Contents listing sheet titles and sheet numbers.

x. Legend and list of abbreviations

y. Submit in Schedule format a detailed list of all spare parts to be provided per the contract documents.

8. Control Logic Documentation

a. Include written description of each control sequence.

b. Include control response, settings, and setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits as part of as-built documentation.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

End of Section 25 05 02

Section 25 05 03 – Integrated Automation System Project Record Documents

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

F. Section 25 05 05, Integrated Automation System Training

G. Section 25 10 01, Integrated Automation System Networks

H. Section 25 10 02, Integrated Automation System Computer Systems, MMI

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Record Documents

A. Provide record copies of product data and control Shop Drawings updated to reflect the final installed condition.

B. Provide record copies of control logic sequences. Accurately record actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of Shop Drawings and including changes to programs made during specified testing.

C. Provide as-built network architecture Drawings showing all nodes including a description field with specific controller identification, description and location information.

D. Record copies shall include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring. Indicate device instance, logical address and drawing reference number.

E. Provide record riser diagram showing the location of all controllers.

F. Maintain Project record documents throughout the Warranty Period and submit final documents at the end of the Warranty Period.

G. Record copies and as-built documentation to be submitted electronically in Visio and PDF format.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

End of Section 25 05 03

Section 25 05 04 – Integrated Automation System Start-Up and Verification

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 05, Integrated Automation System Training

G. Section 25 10 01, Integrated Automation System Networks

H. Section 25 10 02, Integrated Automation System Computer Systems, MMI

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Pre-Installation Quality Control

A. Pre-Installation Programming, Configuration and Testing

1. Equipment Controllers (EC) and Terminal Controllers (TC) shall be programmed, configured and tested prior to installation.

    a. Programming, configuration and testing to be performed at Contractor’s premises.

    b. I/O testing may be performed using software simulated inputs and outputs.

2. Owner Furnished Building Operations Server (BOS) will be made available for contractor use within 30 calendar days following issue of LOI.

3. Contractor to install and configure specified software on BOS prior to installation.

3.2 IAS Field Quality Control

A. Commissioning: See Commissioning Specification Sections for testing details.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.

2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.

3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

5. Fiber-Optic System Test Equipment: Use a fiber-optic time domain reflectometer for testing of length and optical connectivity (where applicable).

6. Test Results: Record test results and submit copy of test results for Project record.

3.3 IAS System I/O Checkout Procedures

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.

2. Verify that control dampers are installed correctly for flow direction.

3. Verify that proper blade alignment, either parallel or opposed, has been provided.

4. Verify that damper frame attachment is properly secured and sealed.

5. Verify that damper actuator and linkage attachment is secure.

6. Verify that actuator wiring is complete, enclosed and connected to correct power source.

7. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.

2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that valve ball, disc or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:
    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.4 IAS System I/O Adjustment, Calibration and Testing

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.5 Final Review

A. Submit written request to Architect when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Architect shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:
    a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
    b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
    c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
    d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
    e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
    f. Trends, summaries, logs and reports set-up for Project.

g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

i. Software's ability to edit control programs off-line.

j. Data entry to show Project-specific customizing capability including parameter changes.

k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

l. Execution of digital and analog commands in graphic mode.

m. Spreadsheet and curve plot software and its integration with database.

n. Online user guide and help functions.

o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

p. System speed of response compared to requirements indicated.

q. For Equipment and Terminal Controllers:

    1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.

    2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and PDA. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

    3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.

    4) Electric Power: Ability to disconnect any controller safely from its power source.

    5) Wiring Labels: Match control drawings.

    6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.

    7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

End of Section 25 05 04

Section 25 05 05 – Integrated Automation System Training

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

G. Section 25 10 01, Integrated Automation System Networks

H. Section 25 10 02, Integrated Automation System Computer Systems, MMI

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Training

A. Instructions

1. Provide instruction to designated personnel in adjustment, operation, maintenance and pertinent safety requirements of Integrated Automation System installed.

2. Training to be project-specific and relevant to the Integrated Automation System described in the related sections above and in the project plans/drawings.

B. Time for Training

1. Contractor to include with their project pricing a minimum of 16 hours of instructional time for owner instruction.

2. Training to occur at time and location determined by owner. Training session lengths to be at owner's discretion.

C. Training Materials

1. Provide equipment, visual/audio aids and materials for classroom training.

2. Provide as-built controls submittals in electronic format for each trainee – See Section 25 05 02 for requirements.

a. Review contents of submittals in detail to explain aspects of operation and maintenance.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

End of Section 25 05 05

Section 25 10 01 – Integrated Automation System Networks

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

G. Section 25 05 05, Integrated Automation System Training

H. Section 25 10 02, Integrated Automation System Computer Systems, MMI

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Networks

A. Building Device Level Network (DLN)

1. The DLN shall be a minimum 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, SOAP, OBIX, SNMP and SMTP Protocols for maximum flexibility for integration of building data with enterprise information systems and providing support for Building Operations Server(s) (BOS), Equipment Controllers (EC) and Terminal Controllers (TC). DLN minimum physical and media access requirements:

    a. Ethernet; IEEE standard 802.3

    b. Cable; 100 Base-T, UTP-8 wire, category 6 minimum

    c. Minimum throughput; 100 Mbps

2. DLN Network Management

    a. The entire DLN shall be managed from a single point utilizing built-in software.

    b. There shall be a single login to view and manage the entire web browser-based networking system.

    c. The entire system shall be managed via single-management IP address.

    d. DLN Network Manager user interface shall be:

        1) Web Browser-Based

        2) Locally hosted on the networking equipment

        3) Displayed in graphical format

        4) Capable of supporting all required operations via point-and-click interaction

        5) Capable of supporting bulk configuration of:

a) PoE Enable/Disable

b) VLAN Configuration/ID

c) PoE Scheduling

d) Port Status Enable/Disable

e) Port Label Text Description

f) Switch Label Text Description

g) Switch Status Enable/Disable

h) Port Security MAC Filter

i) System Name Text Description

j) System Detail Text Description

6) The GUI shall display the manufacturer name of all connected devices.

7) The user shall be able to perform a PoE reset for any individual device in the system with a single click from the GUI.

8) The tables in the GUI shall be sortable and filterable based on relevant data, including but not limited to:

a) PoE Enable

b) Text Description

c) VLAN

d) Connection Status

9) The system shall provide a backup and restore mechanism in a user editable format i.e., CSV.

10) The system shall support the ability to create a summary report with all port configurations.

11) The system shall support bulk firmware upgrades for all edge switches in one operation.

12) The system shall allow system-wide auto-creation of a VLAN simply by specifying one or more ports to be on that VLAN, and automatically ensure that traffic passes between the selected ports. There must not be any restriction on port location.

3. DLN Network Security

a. The system shall support the ability to enable port security, per port, per switch or per system.

b. The system shall support port security (MAC filtering) including for port connected to a daisy-chain of IP devices.

4. Network Hardware

a. Supports creation of single virtual switches consisting up to 1028 ports.

b. Supports both Ethernet and Power over Ethernet (PoE)

c. Supports fiberoptic backbone(s) with Single-strand, Single-mode Optical Fiber OS1/OS2 9/125 µm, with a reach of up to 12.5 miles

d. BACnet protocol specific network traffic

5. Redundancy

a. The system shall support the following for network redundancy:

1) Aggregation Switches

2) Spanning Tree Protocol

3) Fiber Path Redundancy

B. Subnetworks

1. Provide subnetworks for direct digital controllers and BACnet enabled field devices subordinate to Equipment Controllers (ECs) and Terminal Controllers. These subordinate devices typically include equipment such as boilers, chillers, variable frequency drive, flow meters and BTU meters. Sub-networks shall that operate on the following protocol using the specified physical layers:

a. Subnetworks shall employ the BACnet protocol for communication between controllers. BACnet protocol implementation shall adhere to the ANSI/ASHRAE Standard 135. Communications between BACnet devices shall be 76.8 kbps over approved twisted shielded pair cabling utilizing Master/Slave Token Passing BACnet protocol. BACnet defines a comprehensive set of object types and application services for communication requirements among all levels of control in a distributed, hierarchical Building Automation System. BACnet is intended to provide a single, uniform standard for the EMCS to provide the required interoperability.

2. Strict adherence to industry standards including ANSI/ASHRAE Standard 135, BACnet, certified by BACnet Testing Laboratory (BTL listed) to assure interoperability between all system components. Controllers that are not BTL listed are unacceptable.

PART 2 - PRODUCTS

2.1 Manufacturers

A. Optigo Networks

B. Approved Equals

2.2 Operations Switch/Small Facility Aggregation Switch

A. Basis of Design: Optigo Networks ONS-CD0840GP

1. Hardware

a. Port Configuration:

1) (8) RJ45, 10M/100M/1G configurable with PoE+

2) (4) SFP Uplink, 100M/1G configurable

3) (1) Digital Input

4) (1) Digital Output

5) (1) RJ45 Console Port

b. Performance:

1) 17,856 Mpps Forwarding Capacity

2) 24 Gbps Switching Capacity

c. Environmental Range:

1) Operating Temperature: -40 to 167 degrees F

2) Operating Humidity: 5% to 95% non-condensing

d. Mounting Configuration:

1) DIN rail

e. Operating Power:

1) 48 to 54 VDC

2) Max 30W output

2. Software:

a. Ring Management:

1) ITU-T G.8031 Ethernet Linear Protection Switching

2) ITU-T G.8032 Ethernet Ring Protection Switching

3) Rapid Ring w/ Self Recover Time < 20ms

b. Device Management System (DMS):

1) Graphical Monitoring with:

a) Topology View

b) Floor View

c) Map View

2) Search and Switch Management Functions

3) Traffic Monitoring with Visual Chart Display

4) Troubleshooting Tools

a) Network diagnostics

b) Protection Mechanisms (ex. Rate-limiting)

c) Performance Management and Link Management

c. Ethernet OAM

d. Layer 2 Switching with Spanning Tree Protocol and VLAN

e. Layer 3 Switching with IPv4 and IPv6 Static Routing

2.3 Network Controller

A. Basis of Design: Optigo Networks NC-600

1. Hardware:

a. Ports:

1) (1) 10/100/1000 Mbps Management Port

2) (5) 10/100/1000 Mbps Ethernet Ports

3) (1) RJ45 Console Port
4) (2) USB 2.0 Ports

b. Power:
1) 100-240 VAC @ 50-60 Hz
2) Max 150W Power Supply

c. Cooling Fan with fan speed control

d. LCD with keypad

e. Internal Real-Time Clock with Lithium Battery

f. Environmental Range:
1) Operating Temperature: -4 to 104 degrees F
2) Operating Humidity: 5% to 95% non-condensing

g. Mounting Configuration: Rack mounted

2. Software:

a. Optigo Oneview Network Management Software

b. Switch Management for up to 256 devices

c. Software update via USB or WebGUI

d. Web Server with HTTP/HTTPS access

e. Optigo ONS-SW-100P software license to manage up to 100 switch ports (non-expiring)

2.4 Communications Wiring

A. Category 5E Data Communication Cable:

a. Conductors
1) Solid soft drawn bare copper, ASTM B3
2) 24 AWG, 4 Pair, Twisted

b. Insulation and Jacket
1) UL listed Type CMP (Communications Multipurpose, Plenum)
2) Custom Neon Green Color

c. Standards
1) UL 444, 1666
2) TIA/EIA-568-B.2
3) ISO/IEC-11801

d. Terminations
1) RJ45

PART 3 - EXECUTION

3.1 General

A. Installation to be to manufacturer's recommendations.

B. Install equipment, wiring and raceway horizontally, vertically and parallel to walls wherever possible.

C. Provide sufficient slack and flexible connections to allow for servicing of connections.

D. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1, Article 100, Part A.

E. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

F. Contractor shall arrange for work inspection by authorities having jurisdiction over the work.

3.2 Communications Wiring

A. Communication wiring shall be low-voltage Class 2 wiring.

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

1. Runs that are longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

G. Label communication wiring to indicate origination and destination.

End of Section 25 10 01

Section 25 10 02 – Integrated Automation System Computer Systems, MMI

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

G. Section 25 05 05, Integrated Automation System Training

H. Section 25 10 01, Integrated Automation System Networks

I. Section 25 30 01, Integrated Automation System Field Controllers

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Summary

A. Owner furnished, Contractor programmed and installed server (Building Operations Server, BOS) shall be provided for centralized system control, information management, alarm management and data base management functions.

B. All real time control functions shall be resident in the standalone Building Operations Server (BOS) and local controllers (ECs and TCs).

C. Building Operations Server shall be provided complete with software as detailed within this Section.

PART 2 - PRODUCTS

2.1 Building Operations Server Hardware

A. The owner-furnished Building Operations Server shall be an APC PowerEdge R450 Server with Intel Xeon Gold 5317 3G 12 core 3.6 GHz processor with 32GB RAM and (4) 960GB SSD drives in a Raid 5 configuration. Server will be provided with a quad port OCP NIC 3.0 for device level network connections and iDRAC for remote server management.

2.2 Building Operations Server Software

A. Owner Furnished and Configured Software:

1. Windows Server 2019 64-bit operating system.

B. Contractor Furnished and Configured Software:

1. Server platform with integrated control, supervision, data logging, alarming, scheduling and network management. Platform to operate using the Niagara 4.11 framework and shall be suitable for installation in a Windows Server 2019 environment. System to be capable of streaming data and graphical displays to a standard web browser via Ethernet. Basis of Design: Distech EC-Net 4 Supervisor.

2. The software shall employ browser-like functionality for ease of navigation.
    a. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database.
    b. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills.
        1) These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
3. Tagging:
    a. Software shall include a point and device identification system capable of supporting advanced queries of the Integrated Automation System.
4. Real-Time Displays:
    a. Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.
    b. Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.
    c. The graphic shall provide for the ability to command each point, including both timed and permanent overrides.
    d. Provide for all information represented in the graphics in an associated graphical table with links to the equipment graphics and command-able points.
5. The Operator software, shall at a minimum, support the following graphical features and functions:
    a. Graphic screens shall be developed using GIF, PNG, JPG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
    b. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
    c. Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.
6. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
    a. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    b. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
7. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
8. Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analog objects, such as set points. No entry of text shall be required.

9. System Configuration:
    a. At a minimum, the Operator software shall permit the operator to perform the following tasks, with proper password access:
        1) Create, delete or modify control strategies.
        2) Add/delete objects to the system.
        3) Tune control loops through the adjustment of control loop parameters.
        4) Enable or disable control strategies.
        5) Select points to be alarm-able and define the alarm state.
        6) Select points to be trended over a period of time and initiate the recording of values automatically.
10. On-Line Help:
    a. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.
        1) On-line help shall be available for all applications and shall provide the relevant data for that particular screen.
        2) Additional help information shall be available through the use of hypertext.
        3) All system documentation and help files shall be in HTML format.
11. Security:
    a. Each operator shall be required to log on to that system with a user name and password in order to view, edit add, or delete data.
    b. System security shall be selectable for each operator.
    c. The system administrator shall have the ability to set passwords and security levels for all other operators.
    d. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object.
    e. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.
    f. This auto log-off time shall be set per operator password.
    g. All system security data shall be stored in an encrypted format.
12. System Diagnostics:
    a. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.
    b. The failure of any device shall be annunciated to the operator.
13. Alarm Console:
    a. The system shall be provided with a dedicated alarm window or console.
        1) This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

2) The use of the Alarm Console can be enabled or disabled by the system administrator.

a) When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

3) This window will notify the operator of new alarms and un-acknowledged alarms.

b. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

14. Operator’s software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming.

a. This system shall provide the capability to configure controller binary and analog inputs/outputs.

15. The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.

a. Graphics generation shall be done using standard Windows packages.

b. No proprietary graphics generation software shall be needed.

16. Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.

17. The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information.

a. All requests for status, analog, graphic displays, logs, and control shall be selected from the operator's console.

b. The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection.

c. The facilities shall be provided to permit the operator to perform the following tasks:

1) Automatic logging of digital alarms and change of status message.

2) Automatic logging of all analog alarms.

3) System changes (alarm limits, set-points, alarm lock-outs, etc.).

4) Display specific points as requested by the operator.

5) Provide reports as requested by the operator and on Scheduled basis where so required.

6) Display graphics as requested by the operator.

7) Display of help information.

8) Provide trend logs as required by the operator.

9) Provide manual control of digital and analog outputs as required by the operator.

10) Direct the hard copy output of information to the device selected by the operator.

11) Data displayed on monitor to cyclic update as appropriate.

18. Online changes:

a. Alarm limits.

b. Setpoints.

c. Dead-bands

d. Changes/deletions/additions of points.

e. Control and change of state changes.

f. Time of day, day, month, year.

g. Control loop control description changes.

h. Control loop tuning changes

i. Schedule changes

j. Changes/additions/deletions to system graphics

k. Changes/additions/deletions to total systems

19. It shall be possible for the operator to override automatic analog and digital output commands.

    a. Where the IAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic IAS control of any particular output and to originate a manual analog or digital output command.

    b. The provision shall exist for the operator to return analog or digital output command functions to automatic IAS software control.

    c. It shall be possible for the operator to place any computed system setpoint to a computed basis as and when required.

    d. All above functions shall operate under the password protection system.

20. A vocabulary of at least 25 different descriptions using at least six alphanumeric characters to identify engineering units for analog input and output points. Typical description is as follows: %, ˚C, KPA, KW, KWH, L/S, CFM, ˚F, and PSI.

    a. The descriptions shall be alterable from the operator interface with the system on-line.

21. Upon operator's request, the system shall present the condition of any single point, any system, and area or the whole system on user interface.

    a. Analog values and status displayed on the user interface shall be updated whenever new values are received.

    b. Points in alarm shall be flagged by blinking, inverse video different color, bracketed, or by some other means to differentiate them from points not in alarm.

22. Error Messages

    a. Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of EMCS.

    b. Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

23. Password Protection

    a. Provide security system that prevents unauthorized use unless operator is logged on.

    b. Access shall be limited to operator’s user interface functions unless user is logged on, including displays as outlined above.

c. Provide security for 100 users minimum.

d. Each user shall have an individual User ID, User Name and Password.

e. Entries are alphanumeric characters only and are case sensitive (except for User ID).

f. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access.

g. All passwords, user names, and access assignments shall be adjustable online at the operator user interface.

h. Each user shall also have a set security level, which defines access to displays and individual objects the user may control.

i. System shall include 10 separate and distinct security levels for assignment to users.

24. Trend Data

a. System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the Building Operation Server SSD.

1) Archived files shall be appended with new sample data, allowing samples to be accumulated over 5 years.

2) Systems that write over archived data shall not be allowed, unless limited file size is specified.

3) Samples may be viewed at the operator's terminal in a trend log.

4) Logged data shall be stored in spreadsheet format.

5) Operator shall be able to scroll through all trend log data.

6) System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically.

7) All trend log information shall be displayed in standard engineering units.

b. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colors and these Graphs shall show object type value relative to time.

25. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colors and these Graphs shall show object type value relative to time.

26. Operator shall be able to change trend log setup information.

a. This includes the information to be logged as well as the interval at which it is to be logged.

1) Minimum interval of 1 minute.

b. All input, output, and value object types in the system may be logged.

c. All operations shall be password protected.

d. Setup and viewing may be accessed directly from any and all graphics object is displayed on.

27. System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk.

a. Archive files shall be appended with the new data, allowing data to be accumulated over 5 years.

b. Systems that write over archived data shall not be allowed unless limited file size is specified.

c. System shall automatically open archive files as needed to display archived data when operator scrolls through the data.

d. Display all energy log information in standard engineering units.

28. System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time.

    a. All data shall be stored in spreadsheet format for direct use by third-party spreadsheet or other database programs.

    b. Operation of system shall not be affected by this operation.

29. Operator shall be able to change the energy log setup information.

    a. For meters to be logged, include meter pulse value, and the type of energy units being logged.

    b. All meters monitored by the system may be logged.

    c. All operations shall be password protected.

30. Graphics:

    a. The operator's workstation shall display all data associated with the project.

    b. The operator's user interface software shall accept, GIF, PNG, JPG and ICO format graphic files for display purposes.

    c. Graphic files shall be created using scanned, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings.

    d. Operator's workstation shall display all data using 2-D or 3-D graphic representations of all mechanical equipment.

    e. Displays can be used as templates to produce other displays

31. System shall be capable of displaying graphic file, text, and dynamic object data together on each display.

    a. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.

    b. All information on any display shall be dynamically updated without any action by the user.

    c. User interface shall allow user to change all field-resident IAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display.

    d. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

32. All displays shall be generated and customized in such a manner by the local IAS integrator to fit the project as specified.

    a. Canned displays shall not be acceptable.

    b. Displays shall use Standard English for labelling and readout.

c. Systems requiring factory programming for graphics are specifically prohibited.

d. The installing contractor without factory dependency or assistance shall support all graphics and IAS programming locally.

33. Binary objects shall be displayed as ON/OFF/NULL or with customized text.

a. Text shall be justified left, right or center as selected by the user.

b. Allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic.

c. Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm.

d. For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object's status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp).

e. Additionally, allow binary objects to be displayed as an animated graphic.

34. Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.

a. For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation.

b. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF.

c. Allow operator to change bitmap file assignment and also create new and original bitmaps online.

d. System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator.

e. Systems that do not allow customization or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed.

35. Analog objects shall be displayed with operator modifiable units.

a. Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic.

b. Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps.

c. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint.

d. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box.

e. Selection for display type shall be individual for each object.

f. Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad.

36. Analog objects may also be assigned to an area of a system graphic, where the color of the defined area would change based on the analog objects value.

a. For example, an area of a floor-plan graphic served by a single control zone would change color with respect to the temperature of the zone or its deviation from setpoint.

b. All editing and area assignment shall be created or modified online using simple icon tools.

37. A customized menu label (push-button) shall be used for display selection.

    a. Menu items on a display shall allow penetration to lower-level displays or additional menus.

    b. Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item.

    c. Each display may be protected from viewing unless operator has appropriate security level.

    d. A separate security level may be assigned to each display and system object.

38. A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

39. Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.

    a. The presentation will contain, at a minimum, displays for:

        1) Specific Building(s)

        2) Floor plates within Building(s)

        3) Each controlled Zone

        4) Each controlled System or Sub-System

        5) Other specific displays as required by the project as shown within project drawings.

40. All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)

    a. Connecting to the Building IAS displays the specific building display.

    b. Clicking on a floor, displays the floor plate display

    c. Clicking on a zone, displays the specific control system for that zone.

    d. Clicking on a specific system or sub-system coarse representation at the floor plate display level displays a detailed presentation of the system or sub-system.

41. Displays are stored on the Building Operations Server and may be modified on site or via remote communications.

42. Entire system shall operate without dependency on external connections, including enterprise level servers.

43. Alarms:

    a. Operator's terminal shall provide audible, visual and electronic means of alarm indication.

    b. Any alarm may be handled based on its individual or assigned class actions.

        1) Actions are, but not limited to:

            a) Display on the Alarm console.

                i. The system shall be provided with a dedicated alarm window or console.

ii. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

iii. The use of the Alarm Console can be enabled or disabled by the system administrator.

iv. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

v. This window will notify the operator of new alarms and un-acknowledged alarms.

vi. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

b) Delivery by electronic mail (e-mail).

i. Sent via e-mail to one or more recipients.

c. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the Building Operations Server.

1) Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

d. Alarm messages shall be in user-definable text English or other specified language) and shall be entered either at the operator's terminal or via remote communication.

44. Scheduling:

a. Operator's terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.

1) This includes all ON/OFF times (to the minute) for each day's events.

b. Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.

1) These specialty schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, again allowing easy data entry.

2) Exception schedule data is entered by the following methods:

a) Date entries (one day entries)

b) Date-to-Date (a range or span of days)

c) By weekday (for example, a given day of a given week each month)

3) User shall be able to scroll easily through the months for each year as a minimum.

c. At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

45. Archiving:

a. Provide back-up copies of all controller databases to Owner for off-site storage.

b. Provide continuous supervision of integrity of all controller databases.

1) Data base back up and downloading to occur without operator intervention.

c. Operator to be able to manually download entire controller database or parts thereof.

46. Reports:

a. Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.

1) Output to be sorted by area, system point.

b. Periodic/Automatic Report:

1) Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.

2) The software will allow the operator to modify the periodic/automatic reporting profile at any time.

47. As a minimum, the following reports shall be configured on the system:

a. Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency and it shall be possible to select points on the following basis:

1) All points in all areas

2) Area (all points in area)

3) Area system (all points in system)

4) Area system point (individual point)

5) System (all points by system and point type)

6) System point (all points by system and point type)

7) Area point (all points by area and point type).

48. Summary Report:

a. To permit the display or printing of the dynamic values for the user specified points.

1) Reports to be available on same basis as dynamic reports.

b. Output will be to the user selected output device.

49. Trend Reports:

a. To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

50. Historical Data Collection:

a. Provision shall be made to ensure historical data is not lost.

1) The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided.

2) Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.

51. Critical Alarm Summary:
    a. Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.
52. Maintenance Alarm Summary:
    a. Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.
53. Alarm Summary:
    a. Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.
54. Disable Point Summary:
    a. Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.
55. Run Time Summary:
    a. Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.
56. Schedule Summary:
    a. Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.
57. User Record Summary:
    a. Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

2.3 Equipment Controller (EC)/Terminal Controller (TC) Software

A. Software basis of design: Distech EC-gfxProgram.

B. The Programming software must be able to be seamlessly launched from within the Niagara Framework as a wizard.
    1. Connection methods (Tunneling or by building controller – not direct to controller).

C. Provide programming software for the Equipment Controllers (EC) and Terminal Controllers (TC) that allows for the development of control logic and point management and Graphical User Interface screens.
    1. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens.
    2. Access to these functions shall be provided through Graphical User Interface software (GUI).
    3. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool.
    4. Completed applications may be stored in the library for future use.
    5. Graphical User Interface screens shall be created in the same fashion.

6. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates.
7. Any real-time data value or object property may be connected to display its current value on a user display.
8. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
9. Programming Methods:
    a. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application.
    b. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another.
10. Object links will support one-to-one, many-to-one, or one-to-many relationships.
11. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.

D. Object Configuration:
    1. Each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons.
    2. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

E. The software shall provide the ability to view the logic with values being inputted to and outputted from the graphical blocks in real time. (debug mode)

F. The system shall support object duplication within a client’s database.
    1. An application, once configured, can be copied and pasted for easy re-use and duplication.
    2. All links, other than to the hardware, shall be maintained during duplication.

G. Provides function to compare and calculate from multiple values from networked controllers (BOS, EC and/or TC).

H. As a minimum, the function shall calculate and compared the values and return the average, sum, highest, lowest, 3 highest, 3 lowest values and multi-state value count.

I. System shall support auto-linking of objects to graphics.

J. System shall allow for uploading/downloading to/from multiple controllers simultaneously.

2.4 Utility Software

A. Software products shall be provided to allow the owner to access and manipulate the control schematic diagrams and to access product data sheets in an electronic format.

PART 3 - EXECUTION (Not Used)

End of Section 25 10 02

Section 25 30 01 – Integrated Automation System Field Controllers

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

G. Section 25 05 05, Integrated Automation System Training

H. Section 25 10 01, Integrated Automation System Networks

I. Section 25 10 02, Integrated Automation System Computer Systems, MMI

J. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

PART 2 - PRODUCTS

2.1 General

A. Equipment Controllers shall be Owner furnished and contractor installed.

B. All controllers shall meet the following minimum requirements:

1. IP Communication (BACnet/IP)

a. BACnet/IP communication protocol shall be used for all controllers (including terminal devices such as VAVs, FCUs, etc.)

b. Support for IPv4 addressing

c. DHCP support and Auto DNS

d. Baud rate of not less than 100 Mbps

e. 2 - RJ45 ports each capable of supporting 10/100 Base-T.

1) Support of controller daisy chaining on the Ethernet network via integral switch functionality.

2) Integrated fail-safe should allow for communication when the controller is powered down.

f. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (such as JACE, NAE, etc.) and shall be capable of assuming all responsibilities typically assumed by a Network Control Unit.

1) Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

2) The resulting network will be a 'Flat' topology with all devices (controllers, workstations, …) connecting at the same physical network level.

C. Control Panels:

1. Indoor control cabinets located in offices or dry/dust free environments shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.
2. All outdoor control cabinets and control cabinets shall be NEMA 3R construction. All control panels located in mechanical/electrical rooms shall be NEMA 12 construction.
3. Control panels containing more than 4 controllers shall be provided with a terminal strip for field wiring. All control wiring inside the panel shall be between a terminal strip and controller inputs/outputs. All field control wiring shall be terminated at the terminal strip. Field control wiring inputs/outputs shall never be run directly to inputs/outputs of controller.

2.2 Equipment Controllers

A. Equipment Controller (Large)

1. Typical Applications:
   a. Central Station Air Handling Units
   b. Chilled Water Systems
   c. Heating Water Systems
2. Basis of Design: Distech ECY-S1000
3. Characteristics:
   a. Controller with remotely accessible embedded graphics, alarms, trend log, scheduling support and email notification capabilities.
   b. Expandable with capability to support up to 20 input/output modules (320 I/O) and support for BACnet MS/TP, Modbus RTU and Modbus TCP.
   c. Ethernet Communication enabled, 10/100 Mbps, Cat 5e, IPv4 addressing. (2) switched RJ-45 ports.
   d. BTL, B-BC BACnet listed with version 4.4.93 or later.
   e. Web Server Enabled with HTML5 Server Protocol and Restful API Application Interface.
   f. Processor with performance greater than or equal to Sitara ARM, 1GHz CPU speed.
   g. Minimum 4GB Non-volatile Flash memory for applications and storage with minimum 512MB RAM.
   h. Real Time Clock with rechargeable battery and SNTP network time synchronization support.
   i. Real Time Clock battery with 20-hour charge cycle and 20-day discharge time.
   j. (2) USB 2.0 Ports.
   k. (1) Micro-USB 2.0 Port.
   l. 24VAC/DC power supply.
   m. 32 to 122F operating temperature, 0% to 90% RH operating humidity, MTTF 10+ years.
4. Expansion Modules:

a. Communications Module:

1) Communication module shall be capable of RS-485 communication with the following requirements, without the additional gateways/routers to enable RS-485 communication.

2) Module shall include two separate RS-485 communication ports.

3) Allow for either Modbus RTU or BACnet MS/TP communication on either of the ports

4) Allow for a minimum of 32 Modbus RTU communicating devices and/or a minimum of 50 BACnet MS/TP communicating devices to be connected on each RS-485 segment.

b. I/O Expansion Module:

1) Each I/O expansion module shall be capable of monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

a) Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

b) Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

i. The analog or universal input shall use a 16 bit A/D converter.

i) Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

2) Each I/O expansion module shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

a) Digital outputs including Form C relay outputs and Triac outputs

b) Analog outputs of 4-20 mA and 0-10 Vdc.

i. The analog or universal output shall use a 10 bit D/A converter.

c) Outputs shall be provided with HOA (Hand, Off, Auto) support.

3) Each completed configuration of I/O modules shall have a minimum of 10% spare capacity for each point type for future point connection.

a) Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

b) As a minimum, provide one of each type of point available on the controller.

4) Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

5) Any software required for programming shall be unlicensed and openly available

6) Power and Environmental Requirements:

a) 24 VAC with local transformer power.

b) The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

B. Equipment Controller (Medium)

1. Typical Applications:

a. Small Single Zone Air Handling Units

2. Basis of Design: Distech ECY-303

3. Characteristics:

a. Controller with remotely accessible embedded graphics, alarms, trend log, scheduling support and email notification capabilities.

b. Ethernet Communication enabled, 10/100 Mbps, Cat 5e, IPv4 addressing. (2) switched RJ-45 ports.

c. BTL, B-BC BACnet listed with version 4.4.93 or later.

d. Web Server Enabled with HTML5 Server Protocol and Restful API Application Interface.

e. Processor with performance greater than or equal to Sitara ARM, 600 MHz CPU speed.

f. Minimum 4GB Non-volatile Flash memory for applications and storage with minimum 512MB RAM.

g. Real Time Clock with rechargeable battery and SNTP network time synchronization support.

h. Real Time Clock battery with 20-hour charge cycle and 20-day discharge time.

i. (2) USB 2.0 Ports.

j. (1) Micro-USB 2.0 Port.

k. 24VAC/DC power supply.

l. -40 to 122F operating temperature, 0% to 90% RH operating humidity, MTTF 10+ years.

m. (8) Software Configurable Universal Inputs, 16-bit analog to digital converter input resolution with 18VDC, 80mA maximum power supply output and auto-reset fuse for 24VAC protection. Configurable for the following functions:

1) Dry Contact

2) Dry Contact Counter, 1Hz maximum, 500ms On/500ms Off minimum duty cycle.

3) 0 to 10 VDC, 40 kΩ input impedance.

4) 0 to 5 VDC, high input impedance.

5) 0 to 20mA, 249Ω external resistor wired in parallel.

6) Resistance/Thermistor Input, 0 to 350kΩ range. Pre-configured for the following sensor types:

a) Thermistor, 10 kΩ

b) Platinum RTD, Pt1000

c) Nickel RTD, Ni1000

n. (2) Software Configurable Universal Outputs, 10-bit digital to analog converter output resolution with built-in snubbing diode for back-EMF protection, internal short-circuit protection and auto-reset fuse for 24VAC protection. Configurable for the following functions:

1) 12VDC On/Off, Maximum 20mA at 12VDC source current.

2) PWM, 2 to 65 second range with adjustable warm up and cool down time.

3) Floating, 500 millisecond minimum pulse on/off time with adjustable drive period.

o. 0 to 10VDC, 20mA maximum at 10VDC source current, 2.5mA maximum at 1VDC sink current.

p. (4) Digital Outputs, 24VAC Triac, 0.5A continuous duty rated. Configurable for the following functions:

1) 24VAC On/Off.

2) PWM, 2 to 65 second range.

3) Floating, 500 millisecond minimum pulse on/off time with adjustable drive period.

q. (2) Digital-Universal Outputs, configurable to perform functions of either Universal Output or Digital Outputs listed above.

C. Equipment Controller (Small):

1. Typical Applications:

a. Fan Coil Units.

2. Basis of Design: Distech ECY-TU-203

3. Characteristics:

a. Controller with remotely accessible embedded graphics, alarms, trend log, scheduling support and email notification capabilities.

b. Ethernet Communication enabled, 10/100 Mbps, Cat 5e, IPv4 addressing. (2) switched RJ-45 ports.

c. BTL, B-BC BACnet listed with version 4.4.93 or later.

d. Web Server Enabled with HTML5 Server Protocol and Restful API Application Interface.

e. Processor with performance greater than or equal to Sitara ARM, 600 MHz CPU speed.

f. Minimum 4GB Non-volatile Flash memory for applications and storage with minimum 512MB RAM.

g. Real Time Clock with rechargeable battery and SNTP network time synchronization support.

h. Real Time Clock battery with 20-hour charge cycle and 20-day discharge time.

i. (2) USB 2.0 Ports.

j. (1) Micro-USB 2.0 Port.

k. Internal 24VAC power supply, 600mA max, fused short circuit protection with overload protection.

l. 41 to 122F operating temperature, 0% to 90% RH operating humidity, MTTF 10+ years.

m. (3) Software Configurable Universal Inputs. Configurable for the following functions:

1) Dry Contact

2) Dry Contact Counter, 1Hz maximum, 500ms On/500ms Off minimum duty cycle.

3) 0 to 10 VDC, 40 kΩ input impedance.

4) Thermistor Input, 10 kΩ

n. (1) Software Configurable Sensor Input. Configurable for the following functions:

1) Dry Contact

2) Dry Contact Counter, 1Hz maximum, 500ms On/500ms Off minimum duty cycle.

3) Thermistor Input, 10 kΩ

o. (2) Software Configurable Digital Inputs. Configurable for the following functions:

1) Dry Contact

2) Dry Contact Counter, 1Hz maximum, 500ms On/500ms Off minimum duty cycle.

p. (3) Unpowered Relay Outputs, 100-277VAC, 3.0A max current total for three outputs. External fuse protection required. Normally open.

q. (2) 24VAC Triac Outputs, see power supply above.

r. (2) Analog Outputs, 0 to 10VDC, 5mA maximum at 10VDC source current, 2mA maximum at 1VDC sink current.

s. (2) Digital/Analog Outputs, software configurable for Triac or Analog output as listed above.

2.3 Terminal Controllers

A. Terminal Unit Controller:

1. Basis of Design: Distech ECY-VAV (Plenum Rated)

2. Characteristics:

a. Variable air volume terminal unit controller with remotely accessible embedded graphics, alarms, trend log, scheduling support and email notification capabilities.

b. Ethernet Communication enabled, 10/100 Mbps, Cat 5e, IPv4 addressing. (2) switched RJ-45 ports.

c. BTL, B-BC BACnet listed with version 4.4.93 or later.

d. Web Server Enabled with HTML5 Server Protocol and Restful API Application Interface.

e. Minimum 4GB Non-volatile Flash memory for applications and storage with minimum 512MB RAM.

f. Real Time Clock with rechargeable battery and SNTP network time synchronization support.

g. Real Time Clock battery with 20-hour charge cycle and 20-day discharge time.

h. (2) USB 2.0 Ports.

i. (1) Micro-USB 2.0 Port.

j. Internal 24VAC power supply, 7VA nominal power consumption with 20VA full load/peak power consumption and field replaceable fused overcurrent protection.

k. 32 to 122F operating temperature, 0% to 90% RH operating humidity, MTTF 10+ years.

l. On-Board Air-Flow Sensor

1) +/- 2.0 in. W.C. sensing range, polarity-free high-low sensor connection.

2) 0.00007 in. W.C. input resolution.

3) +/- 1.5% airflow accuracy @ >0.05 in. W.C. differential pressure after calibration.

m. (4) Software Configurable Universal Inputs, 16-bit analog to digital converter input resolution with 18VDC, 80mA maximum power supply output and auto-reset fuse for 24VAC protection. Configurable for the following functions:

1) Dry Contact

2) Dry Contact Counter, 1Hz maximum, 500ms On/500ms Off minimum duty cycle.

3) 0 to 10 VDC, 40 kΩ input impedance.

4) 0 to 5 VDC, high input impedance.

5) 0 to 20mA, 249Ω external resistor wired in parallel.

6) Resistance/Thermistor Input, 0 to 350kΩ range. Pre-configured for the following sensor types:

7) Thermistor, 10 kΩ

8) Platinum RTD, Pt1000

9) Nickel RTD, Ni1000

n. (2) Software Configurable Universal Outputs, 10-bit digital to analog converter output resolution with built-in snubbing diode for back-EMF protection, internal short-circuit protection and auto-reset fuse for 24VAC protection. Configurable for the following functions:

1) 12VDC On/Off, Maximum 20mA at 12VDC source current.

2) PWM, 2 to 65 second range with adjustable warm up and cool down time.

3) Floating, 500 millisecond minimum pulse on/off time with adjustable drive period.

4) 0 to 10VDC, 20mA maximum at 10VDC source current, 2.5mA maximum at 1VDC sink current.

o. (4) Digital Outputs, 24VAC Triac, 0.5A continuous duty rated. Configurable for the following functions:

1) 24VAC On/Off.

2) PWM, 2 to 65 second range.

3) Floating, 500 millisecond minimum pulse on/off time with adjustable drive period.

2.4 Sensors

A. Wall Mount Sensors:

1. Basis of Design:

a. Distech Allure EC-Smart-Vue Series

1) EC-Smart-Vue for Temperature Only

2) EC-Smart-Vue-H for Temperature/Humidity

3) EC-Smart-Vue-C for Temperature/Carbon Dioxide

4) EC-Smart-Vue-CH for Temperature/Humidity/Carbon Dioxide

2. Characteristics:

a. Operator Interface: Icon-based with interactive backlit LCD display.

1) Display suitable for use as HVAC equipment configuration and troubleshooting tool.
2) Display to cycle through all measured/controlled values (temperature, humidity and carbon dioxide ppm as applicable).
3) Interface to allow for adjustment of space temperature setpoint.

b. White ABS housing, UL94-V1. Wall surface mount through mounting holes

c. Communications/Power:
1) T568B Cat 5e network cable w/ RJ-45 connector.
2) Device to be provided with input and output connector to allow for pass-through for daisy chain connection of up to 12 total room devices.

d. Temperature Sensor:
1) 10 kOhm NTC Thermistor
2) 41 to 104F range at +/- 0.5F accuracy and 0.18F resolution.

e. Humidity Sensor: +/- 3% accuracy, 1% resolution.

f. Carbon Dioxide Sensor:
1) 0 to 2000 ppm measurement range.
2) Accuracy equal to the greater of +/- 30 ppm or 3% of reading within ranges of 400-1250 ppm carbon dioxide concentration.
3) Stability: Drifty of less than 2% of full scale over 15 year life of sensor.
4) Sensing method: non-dispersive infrared absorption.

B. Ceiling Mount Sensors:

1. Basis of Design:
a. Distech Allure EC-Multi-Sensor-BLE

2. Characteristics:
a. White ABS housing, UL94-V1. Ceiling surface mount.

b. Communications/Power:
1) 16VDC Maximum
2) Power and Communications through T568B Cat 5e network cable w/ RJ-45 connector.

c. Wireless Communication:
1) Bluetooth v4.2.

d. Temperature Sensor:
1) 10 kOhm NTC Thermistor
2) 41 to 104F range at +/- 0.5F accuracy and 0.18F resolution.

e. Luminosity Sensor: Photodiode, 0-4000 lux.

f. Motion Sensor:
1) 16-face Fresnel lens optics.

2) Quad type passive infrared motion sensor element w/ 16’ rated detection distance.

PART 3 - EXECUTION

3.1 Manufacturer's Recommendations

A. Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.2 General Workmanship

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.3 Wiring

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.

B. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC.

C. Low-voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low-voltage power circuits as required to meet Class 2 current limit.

D. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

E. Install wiring in raceway where subject to mechanical damage, where exposed in occupied spaces and in mechanical, electrical, or service rooms.

F. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

G. Do not install wiring in raceway containing tubing.

H. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 10 ft. intervals

I. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

J. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

K. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

L. Include one pull string in each raceway 1 in. or larger.

M. Use color-coded conductors throughout.

N. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

O. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 in. between raceway and high-temperature equipment such as steam pipes or flues.

P. Adhere to requirements in Division 26 where raceway crosses building expansion joints.

Q. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

R. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

S. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

T. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.4 Communications Wiring

A. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

G. Runs that are longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

H. Label communication wiring to indicate origination and destination.

3.5 INSTALLATION OF CONTROLLERS

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controllers with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.

End of Section 25 30 01

Section 25 35 27 – Integrated Automation System Variable Frequency Drives

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

G. Section 25 05 05, Integrated Automation System Training

H. Section 25 10 01, Integrated Automation System Networks

I. Section 25 10 02, Integrated Automation System Computer Systems, MMI

J. Section 25 30 01, Integrated Automation System Field Controllers

K. Section 25 35 30, Integrated Automation System Tubing, Cabling and Raceway

1.2 Summary

A. This Section includes solid-state, PWM, Variable Frequency Drives for speed control of three-phase, squirrel-cage induction motors.

1.3 Definitions

A. BAS: Building automation system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFD: Variable frequency drive.

G. NRTL: Nationally Recognized Testing Laboratory.

1.4 Quality Assurance

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.5 Delivery, Storage and Handling

A. Store VFD's indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFD's from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.6 Project Conditions

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 0 to 40 deg C (5 deg to 104 deg F).
2. Humidity: Less than 95 percent (noncondensing).
3. Altitude: Not exceeding 3300 feet.

1.7 Coordination

A. Coordinate layout and installation of VFD's with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

C. Coordinate sizing of VFD’s to match horsepower, output amps, and electrical characteristic requirements with submittal data for the equipment being provided on this project.

1.8 Warranty

A. Special Warranty: Manufacturers standard form in which manufacturer agrees to provide onsite parts and labor warranty for a period of two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 Manufacturers

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary Series ACH 580.

2.2 Variable Frequency Drives

A. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.
2. Unit shall be plenum rated.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 90 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:

1. Input ac voltage tolerance of plus or minus 10 percent.
2. Input frequency tolerance of 60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 98 percent at 60 Hz, full load.

4. Minimum Displacement Primary-Side Power Factor: 98 percent.
5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque or as indicated.
7. Speed Regulation: Plus or minus 1 percent.
8. Input Line Impedance: 5 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.

F. Internal Adjustability Capabilities:
1. Minimum Speed: 30 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 1 to a minimum of 1800 seconds.
4. Deceleration: 1 to a minimum of 1800 seconds.
5. Current Limit: 110 percent of maximum rating.

G. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 or 30 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor overtemperature fault.
10. Fast acting drive input fuses.

H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional auto speed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

I. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

J. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

K. Input Line Conditioning: VFD shall have an integral 5% impedance line reactor to reduce the harmonics to the power line. The impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors.

L. VFD Output Filtering: Provide output filters when wire length from drive to motor exceeds manufacturer's allowable length. Filters shall be equal to KLC dv/dt Guard, U.L. Listed, in NEMA 1 enclosure.

M. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on – normal operation.
2. Fault.
3. Alarm control

N. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and real time clock.

1. Indicating Devices: Digital LED readout and selector switch, to indicate the following controller parameters:
    a. Output frequency (Hz).
    b. Motor speed (rpm).
    c. Motor status (running, stop, fault).
    d. Motor current (amperes).
    e. Motor torque (percent).
    f. Fault or alarming status (code).
    g. PID feedback signal (percent).
    h. DC-link voltage (VDC).
    i. Set-point frequency (Hz).
    j. Motor output voltage (V).

O. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed setting input signals from the BMS or other control systems:
    a. 0 to 10-V dc.
    b. 0-20 or 4-20 mA.
    c. Potentiometer using up/down digital inputs.
    d. Fixed frequencies using digital inputs (Fireman's override).
    e. RS485.
    f. Keypad display for local hand operation.
3. Output Signal Interface:
    a. A minimum of 2 analog output signal (0/4-20 mA), which can be programmed to any of the following:
        1) Output frequency (Hz).
        2) Output current (load).

3) DC-link voltage (VDC).

4) Motor torque (percent).

5) Motor speed (rpm).

6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 3 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

   a. Motor running.

   b. Fault and warning indication (overtemperature or overcurrent).

   c. Loss of load condition (broken belt / broken coupling).

P. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BAS control. Provide capability for VFD to retain these settings within the nonvolatile memory.

1. Coordinate requirements with controls diagrams and controls contractor to provide BACnet MS/TP interface.

2. Disconnecting Means: Provide VFD's without disconnects.

2.3 ENCLOSURES

A. NEMA Type 1 for general purpose interior dry locations.

B. NEMA Type 3R for exterior or damp locations.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

PART 3 - EXECUTION

3.1 Applications

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller and load.

B. Select horsepower rating of controllers to suit motor(s) controlled. For VFD's serving multiple motors, size VFD according to the sum of the RLA's of all motors.

3.2 Installation

A. Anchor each VFD assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Controller Fuses: Install fuses in each fusible switch.

3.3 Control Wiring Installation

A. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 Connections

A. Conduit installation requirements are specified in Division 26 Sections.

B. Ground equipment according to Division 26.

3.5 Field Quality Control

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following check-out and start-up services:

1. Inspect controllers, wiring, components, connections, and equipment installation. For proper operation and installation of VFD, its options and interface wiring to the BAS.

2. Set field-adjustable switches and circuit breaker trip ranges.

3. Report results in writing.

3.6 Demonstration

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency drives.

End of Section 25 35 27

Section 25 35 30 – Integrated Automation System Tubing, Cabling and Raceway

PART 1 - GENERAL

1.1 Related Sections

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 23 09 23 Series of Specifications for Direct Digital Control Systems

C. Section 25 05 01, Integrated Automation System General Requirements

D. Section 25 05 02, Integrated Automation System Submittals

E. Section 25 05 03, Integrated Automation System Project Record Documents

F. Section 25 05 04, Integrated Automation System Start-Up, Verification and Commissioning

G. Section 25 05 05, Integrated Automation System Training

H. Section 25 10 01, Integrated Automation System Networks

I. Section 25 10 02, Integrated Automation System Computer Systems, MMI

J. Section 25 30 01, Integrated Automation System Field Controllers

PART 2 - PRODUCTS

2.1 Piping and Tubing

A. Pressure Instrument Tubing and Piping:

1. Products in this paragraph are intended for use with the following:
2. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers and accessories.
3. Copper Tubing:
    a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.
    b. Performance, dimensions, weight and tolerance according to ASTM B 280.
    c. Diameter, as required by application, not less than nominal 0.25 inch.
    d. Wall thickness, as required by the application, but not less than 0.030 inch.
4. Copper Tubing Connectors and Fittings:
    a. Brass, compression type.
5. Polyethylene Tubing:
    a. Fire-resistant black virgin polyethylene according to ASTM D 1248, Type 1,
    b. Class C and Grade 5.
    c. Tubing shall comply with stress crack test according to ASTM D 1693.
    d. Diameter, as required by application, of not less than nominal 0.25 inch.
6. Polyethylene Tubing Connectors and Fittings:

a. Brass, barbed fittings.

b. Brass, compression type.

B. Process Tubing:

1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.

2. Copper Tubing:

a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B 75.

b. Performance, dimensions, weight and tolerance according to ASTM B 280.

c. Diameter, as required by application, of not less than nominal 0.25 inch.

d. Wall thickness, as required by application, but not less than 0.030 inch.

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

4. Stainless-Steel Tubing:

a. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.

b. Chemical and physical properties according to ASTM A 269.

c. Diameter, as required by application, of not less than nominal 0.25 inch.

d. Wall thickness, as required by application, but not less than 0.035 inch.

e. Furnish stainless-steel tubing in 20-foot straight random lengths.

5. Stainless-Steel Tubing Connectors and Fittings:

a. Connectors and fittings shall be stainless steel, with stainless-steel collets, flareless type.

b. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on another end.

2.2 Control Wire and Cable

A. Wire: Single or Multiconductor control wire cables:

1. Wire size shall be at least No. 18 AWG.

2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.

3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C with plenum rated outer jacket.

4. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 18 AWG.

2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.

3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.

4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be plenum rated.
6. For twisted pair, conductor colors shall be black and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be plenum rated.
5. For twisted pair, conductor colors shall be black and white.
6. Furnish wire on spools.

2.3 Raceways for Control Wiring, Cabling and Tubing

A. Metal Conduits, Tubing, and Fittings:

1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with NEMA ANSI C80.1 and UL 6.
3. EMT: Comply with NEMA ANSI C80.3 and UL 797.
4. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
5. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
    a. Fittings for EMT:
        1) Material: Steel.
        2) Type: Setscrew.
    b. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
    c. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
6. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

B. Surface Metal Raceways: ** USE ONLY WHERE SPECIFICALLY SHOWN OR PLANS OR AUTHORIZED BY OWNER. OTHERWISE ALL CONTROL CABLE TO BE CONCEALED IN THE WALL CONSTRUCTION. Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color as selected by Owner.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. MonoSystems, Inc.

b. Panduit Corp.

c. Wiremold / Legrand.

C. Control Power Wiring and Raceways

1. Comply with requirements in Division 26 for electrical power conductors and cables.
2. Comply with requirements in Division 26 for electrical power raceways and boxes.

PART 3 - EXECUTION

3.1 Control Wire, Cable and Raceways Installation

A. Comply with NECA 1.

B. Comply with TIA 568-C.1.

C. Wiring Method: Install cables in raceways except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

E. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

F. Conduit Installation:

1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
3. Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet long.
9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.

10. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
11. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
12. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
13. Offset conduits where entering surface-mounted equipment.
14. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
    a. Conduit extending from interior to exterior of building.
15. Conduit extending into pressurized duct and equipment.
16. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

G. Wire and Cable Installation:

1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. Unshielded Twisted Pair (UTP) Cable Installation:
    a. Comply with TIA 568-C.2.
    b. Do not untwist UTP cables more than 1/2 inch from the point of termination, to maintain cable geometry.
6. Installation of Cable Routed Exposed under Raised Floors:
    a. Install plenum-rated cable only.
7. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
8. Provide strain relief.
9. Terminate wiring in a junction box.
    a. Clamp cable over jacket in junction box.
    b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

10. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
11. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
12. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
13. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
14. Wire and cable shall be continuous from terminal to terminal without splices.
15. Use insulated spade lugs for wire and cable connection to screw terminals.
16. Use shielded cable to transmitters.
17. Use shielded cable to temperature sensors.
18. Perform continuity and megger testing on wire and cable after installation.
19. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.
20. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
21. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
22. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:
    a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.
    b. Separation between open cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
23. Separation between cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
24. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

25. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
26. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

H. BACnet MS/TP Sub-Networks

1. When using MS/TP, provide MS/TP networks in accordance with ASHRAE 135 and in accordance with the ASHRAE 135 figure "Mixed Devices on 3-Conductor Cable with Shield" (Figure 9-1.4 in the 2012 version of ASHRAE 135). Ground the shield at the BACnet Router and at no other point. Ground the reference wire at the BACnet Router through a 100 ohm resistor and do not ground it at any other point.
2. Provide each segment in a doubly terminated bus topology in accordance with TIA-485.
3. Provide each segment with 2 sets of network bias resistors in accordance with ASHRAE 135, with one set of resistors at each end of the MS/TP network.
4. Use 3 wire (twisted pair and reference) with shield media for all MS/TP media installed inside. Use fiber optic isolation in accordance with ASHRAE 135 for all MS/TP media installed outside buildings, or between multiple buildings.
5. For 18 AWG cable, use segments with a maximum length of 4000 ft. When using greater distances or different wire gauges comply with the electrical specifications of TIA-485.
6. For each controller that does not use the reference wire provide transient suppression at the network connection of the controller if the controller itself does not incorporate transient suppression.
7. Install no more than 32 devices on each MS/TP segment. Do not use MS/TP to MS/TP routers.
8. For BACnet Routers, configure the MS/TP MAC address to 0. Assign MAC Addresses to other devices consecutively beginning at 1, with no gaps.

End of Section 25 35 30

SECTION 26 05 00

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General Conditions:
1. The accompanying General Conditions (front-end specifications) shall apply to and form a part of this section.

B. General Requirements:
1. Carefully examine General Conditions, other specification sections, and other drawings (in addition to Electrical) in order to be fully acquainted with their effect on electrical work.
2. Do all work in compliance with all applicable codes, laws, and ordinances, the National Electrical Safety Code, the National Electrical Code (hereinafter referred to as "Code"), applicable energy codes, and the regulations of the local utility companies. Obtain and pay for any and all required permits, inspections, certificates of inspections and approval, and the like.
3. Cooperate with other trades and contractors at job. Perform work in such manner and at such times as not to delay work of other trades. Complete all work as soon as the structure and installations of equipment will permit. Patch, in a satisfactory manner and by the proper craft, any work damaged by electrical workmen.
4. Electrical contracting firm shall be licensed as an electrical contractor in the state where work will be performed

1.2 GENERAL SCOPE OF ELECTRICAL WORK (REFER TO DRAWINGS FOR OTHER SPECIFIC SCOPE ITEMS)

A. Furnish all labor and materials to complete electrical work as shown on drawings and/or herein specified.

B. Remove all existing electrical equipment and wiring made obsolete by this project and remove or relocate all electrical services located on or crossing through the project property, either above or below grade, which would obstruct the construction of the project or conflict in any manner with the completed project or any code pertaining thereto. Dispose of salvageable materials as directed by the Architect. Contractor shall schedule meeting to review scope of electrical demolition and to confirm scope and phasing of proposed demolition with the owner in the presence of the prime consultant prior to start of any electrical demolition.

C. Furnish and install complete power, telephone and other electrical services as shown on drawings and/or specified herein.

D. Pay all electrical utility company service charges (if any) in connection therewith, including permanent meter deposit. Meter deposits will be refunded to Contractor at time of Owner's acceptance.

E. Furnish and install complete power distribution system as shown on drawings and/or specified herein.

F. Furnish and install medium voltage power distribution system components as shown on drawings and/or

specified herein.

G. Furnish and install a complete Power Generation and Automatic Transfer Switch System as shown on drawings and/or specified herein.

H. Furnish and install disconnect switches for motors as shown on drawings and/or specified herein.

I. Furnish and install complete electrical grounding systems as shown on drawings and/or specified herein.

J. Install and connect electrical equipment mentioned in Division 26/27/28 Specifications or noted in drawings, whether furnished by electrical contractor or by others.
   1. Where shown or specified, equipment furnished by others shall be installed and connected under this Contract.
   2. Where shown or specified, Contractor shall receive, unpack, check and assume custody of equipment furnished by Others. Contractor shall assume responsibility for care and safekeeping of this equipment, when delivered into his custody. He shall protect it from moisture, dust and damage during construction and until Owner acceptance of project.

K. Furnish and install complete electrical lighting systems as shown on drawings and/or specified herein.

L. Furnish and install all electrical items shown on drawings and/or herein specified, unless shown or specified otherwise.

M. Furnish and install complete controls & auxiliary systems as shown on drawings and/or specified herein.

N. Furnish and install complete telephone/data raceway (including all outlet boxes, face plates, conduit raceways, telephone backboards, terminal cabinets, etc.) system as shown on drawings and/or specified herein.

O. Furnish and install a complete Fire Alarm System as shown on drawings and/or specified herein.

P. Furnish and install a complete Surge Protection System as shown on drawings and/or specified herein.

Q. Furnish and install a complete Building Lightning Protection System as shown on drawings and/or specified herein.

R. Procure and pay for permits and certificates as required by local and state ordinances and fire underwriter's certificate of inspection.

S. Balance loads as equally as practicable on services, distribution feeders, circuits and buses. Provide typewritten directory for each panel.

T. Unless specifically indicated or required otherwise, terminate all circuitry/cabling provided within this contract at associated equipment/devices/etc. in accordance with all applicable codes, standards and supplier requirements, whether associated equipment/device/etc. is furnished within this contract or by others.

U. Complete field testing, adjustment & startup of all systems listed above as shown on drawings and/or

specified herein.

PART 2 - PRODUCTS

2.1 APPROVED MATERIALS AND DEVICES

A. Where not otherwise specified, provide only new, standard, first-grade materials/systems throughout, conforming to standards established by Underwriter's Laboratories, Inc., and so marked or labeled, together with manufacturer's brand or trademark. All equipment/systems subject to approval of Architect before installation. All like items and associated equipment/systems shall be of one manufacturer.

B. To ensure proper coordination, it is intended that all electrical equipment and materials specified in Division 26/27/28 of these specifications and shown on the electrical drawings be furnished and installed by the electrical sub-contractor. It will not be permissible for any of these items to be furnished directly by the general contractor without the electrical contractor's coordination.

C. To ensure commonality of spare parts, it is required that the electrical contractor provide the same brand for all circuit breakers, starters, power equipment, etc. provided under the following divisions of these specifications:
1. SECTION 26 05 73: POWER DISTRIBUTION SYSTEM ELECTRICAL STUDIES
2. SECTION 26 24 16: POWER PANELBOARDS - CIRCUIT BREAKER TYPE
3. SECTION 26 24 17: LIGHTING PANELBOARDS
4. SECTION 26 28 16: SAFETY SWITCHES AND FUSES

2.2 SUBMITTALS

A. All submittals to the design team shall be accompanied by a letter summarizing all proposed deviations from specified products or pre-approved substitutions. The absence of such a letter shall be understood to indicate that the contractor intends to meet all contract requirements, regardless of cut-sheets/data-sheets provided within the submittal.

B. Submit to Architect ten (10) days prior to bid date three (3) copies of any items and/or manufacturers which are proposed as substitutes for those specified.

C. Submit to Architect promptly after award of Contract and prior to purchasing, the number of copies required by the contract. All drawings of a specific item or system shall be made in one submittal, and within thirty (30) days after award of Contract. Shop drawings of all power equipment shall contain exact details of device placement, phasing and numbering, in form of elevations, for each major piece of equipment. Shop drawings shall be submitted on the following:
1. SECTION 26 05 13: POWER CABLES, 601V-38kV
2. SECTION 26 05 73: POWER DISTRIBUTION SYSTEM ELECTRICAL STUDIES
3. SECTION 26 09 43: LIGHTING CONTROL SYSTEM
4. SECTION 26 09 44: DISTRIBUTED DIGITAL LIGHTING MANAGEMENT SYSTEM
5. SECTION 26 24 16: POWER PANELBOARDS - CIRCUIT BREAKER TYPE
6. SECTION 26 24 17: LIGHTING PANELBOARDS
7. SECTION 26 28 16: SAFETY SWITCHES AND FUSES
8. SECTION 26 32 13: GENERATOR SETS
9. SECTION 26 36 23: AUTOMATIC TRANSFER SWITCHES

10. SECTION 26 36 33: GENERATOR LOAD BANK DOCKING STATION
11. SECTION 26 41 00: LIGHTNING PROTECTION SYSTEM
12. SECTION 26 43 00: SURGE PROTECTIVE DEVICES
13. SECTION 26 50 00: LIGHTING MATERIALS AND METHODS
14. SECTION 28 78 00: EMERGENCY RESPONDER RADIO COVERAGE SYSTEM
15. ALL POWER DISTRIBUTION EQUIPMENT (i.e. SWITCHBOARDS, PANELBOARDS, DRY TYPE TRANSFORMER, ETC.)
16. ALL ELECTRICAL AND TELECOMMUNICATION EQUIPMENT LAYOUTS - Submittals shall include ¼" = 1'-0" CAD drawings (hand drawn sketches will not be accepted) of each electrical room, IT room, electrical equipment stand, generator area, or any other similar area with electrical equipment. Drawings shall indicate all panelboards, transformers, switchboards, generators, equipment racks, control panels, HVAC equipment, etc. that are located in each electrical/IT area. Layouts shall show that each piece of electrical equipment has the clearances, working space and dedicated equipment space required by applicable codes. No conduits to equipment within these areas shall be installed until submittals have been provided and returned without exception by the design team.

D. The contractor shall fully review, comment upon and correct all shop drawings as required to assure compliance with contract documents prior to submittal to Architect. The failure of the contractor to properly review and correct shop drawings prior to submittal will result in rejection of shop drawings by the engineer. Review by the Architect will be for general conformance with contract documents. The contractor shall be fully responsible for correctness of all submitted dimensions, details, quantities and locations.

E. None of the above items shall be installed until shop drawings or catalog data have been reviewed by Architect without rejection or required resubmittal. Any listed item not submitted, even if specified, shall be considered not acceptable and shall be removed if directed.

F. Any required resubmittal will be reviewed by the Architect for conformance with previously issued comments only. The contractor shall be responsible for verifying that all items not specifically requiring resubmittal have not been altered from the previously reviewed submittal.

G. Material proposed for substitution shall be of the same quality, perform the same functions, conform to such physical dimensions and appearance as are required by the Architect. All material proposed for substitution is subject to the approval of the Architect and his authority for approval is final. No material proposed for substitution will be considered unless all submittal data complies with the drawings and specifications of Section 16 as to time of submission, number of copies of submittal, and detail requirements.

H. Samples of material shall be furnished where required by drawings or Division 26/27/28 Specification, or as requested by the Architect on items proposed as substitutes.

I. Submit to Architect a certificate of final inspection from local inspection department.

PART 3 - EXECUTION

3.1 SITE VISIT

A. The Contractor shall visit the site to determine existing dimensions and conditions affecting electrical work. Failure to do so in no way relieves Contractor of his responsibility under Contract.

3.2 WORKMANSHIP

A. All work shall be in accordance with the latest editions of NFPA 70 (National Electrical Code), NFPA 101 (Life Safety Code), National Electric Safety Code, International Building Code, applicable NECA standards and the rules and regulations of State and Local Authorities Having Jurisdiction.

B. All work shall be executed in a workmanlike manner and shall present a neat and mechanical appearance upon completion.

C. All equipment, devices, etc. shall be installed in accordance with manufacturer's recommendations.

D. All items shall be installed straight and plumb in a workmanlike manner and care shall be exercised so that like items are mounted the same position, heights and general location.

E. Keep site clean of accumulation of cartons, trash and debris.

3.3 SAFETY

A. The contractor is solely responsible for all job safety. Architect assumes no responsibility for job safety. Maximum consideration shall be given to job safety and only such methods as will reasonably insure the safety of all persons shall be employed. The codes and regulations of OSHA shall be given strict compliance as well as such other codes, laws, and regulations as may be applicable.

3.4 CONTRACT DOCUMENTS

A. Contract documents indicate diagrammatically, extent, general character and approximate location of work. Where work is indicated but minor details omitted, furnish and install it complete so as to perform its intended functions. For details and mechanical equipment, follow drawings provided by other disciplines (Architectural, Mechanical, Structural, Civil, etc.) and fit electrical work thereto.

B. Contract documents consist only of the hardcopy documents issued by the Prime Architect. Electronic documents issued directly by the electrical engineer to the contractor and/or its sub-contractors/vendors are issued for convenience only (electronic documents are not formal contract documents).

C. If the contractor and/or one of its suppliers require a one-time transfer of electronic files of the current electrical construction documents to prepare shop drawings (or for another similar purpose), it shall:
   1. Sign a waiver prepared by the electrical engineer prior to the transmittal of these files.
   2. Agree to pay the electrical engineer a fee of $50.00 per drawing, up to a maximum of $400 per transfer, payable upon receipt of the files.
   3. To the fullest extent permitted by law, indemnify, hold harmless, and defend JRA from all claims, damages, losses and expenses, including attorneys' fees arising out of or resulting from the use of the CAD files.

D. Take finish dimensions at job in preference to scaled dimensions.

E. Except as above noted, make no changes in or deviations from work as shown or specified except on

written order of Architect.

3.5 UNDERGROUND UTILITY/EQUIPMENT COORDINATION

A. Prior to commencement of work, verify exact locations of all existing or proposed underground utilities and/or underground equipment and verify that proposed electrical installation does not conflict with these items. Notify Architect immediately if any conflict is found.

3.6 EQUIPMENT STORAGE

A. Store all electrical equipment in dry, covered locations as directed by equipment manufacturers. Contractor shall be responsible for replacing or repairing improperly-stored equipment as directed by Architect.

3.7 EXCAVATION, CUTTING AND PATCHING

A. Perform all cutting and excavating as necessary for installation of electrical systems, unless specifically covered under another section. After Architect's observation, complete all excavation, filling and backfilling as directed under specifications for preparation of site and earthwork. Foundations for equipment shall be as specified under concrete section. Concrete pads shall be minimum of 6" thick; unless greater thickness required by equipment manufacturer. Obtain specific approval of Architect before cutting into any structural members.

B. For all such work employ competent workmen, and finish up in neat and workmanlike manner, equal to quality and appearance to adjacent work.

3.8 PENETRATIONS

A. All penetrations in water tight barriers shall be made so that barrier rating is not compromised. Furnish roof flashing for all equipment installed under Division 26/27/28 that penetrates through the roof. Appropriate flashing is specified under roofing and sheet metal section. Supply these flashings for installation under roofing and sheet metal section.

B. All fire/smoke barrier penetrations shall be made in accordance with a U.L. listed assembly to maintain the fire/smoke rating of the associated membrane.

C. Where penetrations are required through structural elements, verify penetration locations and sizes with structural engineer. In no case shall the structural integrity be compromised without written approval from structural engineer.

3.9 INSTALLATION OF EQUIPMENT - GENERAL

A. Care shall be exercised in exact routing and location of all items so as not to obstruct access to equipment, personnel walkways, or expose it to potential mechanical damage.

B. Items shall be securely anchored and/or fastened. Provide proper support for all equipment, devices, conduits, boxes, panels, etc. as required by code and for a workmanlike installation. Provide guy wiring for wood poles where required to prevent leaning. All construction shall meet the seismic design requirements of the building code. Items (especially transformers, light fixtures, equipment racks, freestanding gear, etc.) installed in seismic zones C, D, E or F shall be supported and braced per

applicable codes and standards.

C. All wall, pole or frame-mounted electrical equipment shall be mounted to metal unistrut (or similar) frames of same material as electrical equipment. For example, pole-mounted painted or galvanized steel disconnect switches shall be mounted to galvanized steel unistrut frames.

D. All electrical equipment, furnished by Contractor or by others shall be covered and protected during construction.

E. All control cabinets, panels, motor control centers and other electrical cabinets and enclosures shall have all trash removed and be vacuumed clean. All foreign paint, etc., shall be removed from exterior and all scratches in finish touched up with same color and material as original. Any rusted areas shall be sanded, primed and repainted.

F. All relays, starters, push-button and other control devices shall be cleaned and if necessary, lubricated with CRC 2-26 to assure free operation.

3.10 MOTORS, STARTERS AND CONTROLS

A. Unless otherwise specified or shown, all motors will be furnished and installed under other sections of this specification.

B. Electrical Contractor shall install all starters and all electrical power wiring and connections to motors and starters.

C. Unless otherwise specified or shown, all control items for motors shall be furnished, installed and wired in conduit under other divisions of this specification.

3.11 CIRCUITS AND BRANCH CIRCUITS

A. Outlets shall be connected to branch circuits as indicated on drawings by circuit numbers. No more outlets than are indicated shall be connected to a circuit.

B. Branch circuit homeruns shall be installed as shown on drawings. Multiple homerun conduits shall not be combined by contractor into larger, single homerun conduits unless specific permission is granted by the Engineer.

3.12 LUG/TERMINAL RATINGS

A. All lug/terminal ratings, sizes, locations, types, etc. shall be coordinated with the associated conductor sizes, types, routings, etc. by the contractor.

B. All lugs/terminals/etc. shall be rated for 75 degree C terminations (minimum, unless specified otherwise).

3.13 EQUIPMENT FAULT CURRENT RATINGS

A. All equipment and breakers shall meet the minimum RMS symmetrical interrupting capacity ratings shown on plans for the associated distribution equipment. All interrupting ratings shall be full ratings. Where new devices or breakers are added to existing distribution equipment, the new devices/breakers shall have interrupting ratings matching or exceeding that of the existing distribution equipment.

3.14 OUTLET LOCATION

A. Symbols shown on drawings and mounting heights indicated on drawings and in specifications are approximate only. The exact locations and mounting height must be determined on the job and it shall be the Contractor's responsibility to coordinate with other trades to insure correct installation.

3.15 IDENTIFICATION

A. Each panel shall have each circuit identified. Panels without branch circuit nameplates shall have typewritten directories.

B. Each individually mounted switch, circuit breaker, starter and/or any other control or protective device shall identify equipment fed and fuse size, if any, by engraved plastic nameplate, white with black letters, screw attached.

C. See Specification Section 26 05 53 for additional requirements.

3.16 GROUNDING

A. All equipment shall be grounded and bonded in accordance with all state/local regulations, The National Electrical Code and as specified herein.

3.17 TELEPHONE WORK

A. Provide telephone raceways, outlets and backboards, as shown. Provide additional work as shown on drawings. Bond all raceways together at backboards and provide No. 6 ground wire extending from raceway bonds to cold water pipe, in 1/2 inch raceway. Carefully ream ends of all raceways.

3.18 PAINTING

A. Refer to Painting/Finishing specifications for requirements regarding field painting of exposed conduit. Any scratches, dents or rust spots in conduit electrical enclosures, panels, motor control or any other electrical items shall have the dents removed, and they, along with any rust spots or scratches, sanded and touched up with the same exact color paint as original finish.

3.19 ACCEPTANCE TESTING

A. Upon completion of work, the entire electrical system installed within this project shall be tested and shall be shown to be in perfect working condition, in accordance with the intent of the specifications and drawings. It shall be the responsibility of the Electrical Contractor to have all systems ready for operation and to have an electrician available to operate same in accordance with and under the supervision of the observation representative(s) of the Architect. The Electrician shall be available to assist in removal of panel fronts, etc., to permit inspection as required.

B. The electrical sub-contractor shall include in bid price start-up assistance and training from a certified representative of the manufacturer for the following systems:
   1. SECTION 26 09 43: LIGHTING CONTROL SYSTEM
   2. SECTION 26 09 44: DISTRIBUTED DIGITAL LIGHTING MANAGEMENT SYSTEM
   3. SECTION 26 32 13: GENERATOR SETS
   4. SECTION 26 36 23: AUTOMATIC TRANSFER SWITCHES

5. SECTION 26 36 33: GENERATOR LOAD BANK DOCKING STATION
6. SECTION 28 78 00: EMERGENCY RESPONDER RADIO COVERAGE SYSTEM

3.20 OPERATION AND MAINTENANCE DATA

A. One set of marked “AS BUILT” drawings, three (3) sets of all equipment catalog and maintenance data and three (3) sets of all final shop drawings, on all equipment requiring same shall be turned over to owner. These items shall be bound in hard back book. Contractor shall explain and demonstrate all systems to Owner’s representative.

3.21 GUARANTY-WARRANTY

A. Furnish a written Guarantee-Warranty, countersigned and guaranteed by General Contractor, stating:
   1. That all work executed under this section will be free from defects of workmanship and materials for a period of one (1) year from date of final acceptance of this work.
   2. Above parties further agree that they will, at their own expense, repair and replace all such defective work, and all other work damaged thereby, which becomes defective during the term of the Guaranty-Warranty.

END OF SECTION 26 05 00

SECTION 26 05 19

POWER CONDUCTORS AND CABLES 51V-600V

PART 1 - GENERAL

1.1 DESCRIPTION

A. Power Wires and Cables

B. Low Voltage Wires and Cables

PART 2 - PRODUCTS

2.1 POWER WIRES AND CABLES - 600 VOLT

A. General: Conductors shall have current carrying capacities as per N.E.C. and with 600 volt insulation, #12 minimum except for controls and fixture wire. Conductors shall be copper.

B. General Application (see below for exceptions):
   1. At or Below Grade (including within slab-on-grade):
      a. #8 or larger conductors:
         1) XHHW or RHH/RHW/USE stranded (in conduit).
      b. #10 or smaller conductors for circuits terminating at motors:
         1) THHN/THWN or XHHW stranded (in conduit).
      c. #10 or smaller conductors (excluding circuits terminating at motors):
         1) THHN/THWN or XHHW solid (in conduit).
   2. Above Grade:
      a. #8 or larger conductors:
         1) THHN/THWN, XHHW or RHH/RHW/USE stranded (in conduit).
      b. #10 or smaller conductors for circuits terminating at motors:
         1) THHN/THWN, XHHW or RHH/RHW/USE stranded (in conduit).
      c. #10 or smaller conductors (excluding circuits terminating at motors):
         1) THHN/THWN, XHHW or RHH/RHW/USE solid (in conduit).
   3. Power Wire and cable shall be as manufactured by Southwire, Rome, Encore Wire, American Insulated Wire, Okonite, Phelps-Dodge, Amercable, Aetna or approved equal.

C. Emergency Feeder Wiring
   1. Where specifically required by NEC articles 700, 701, or other similar sections, feeder-circuit wiring for emergency systems and legally-required standby systems shall be a listed electrical circuit protective system consisting of 2-hour fire-rated, mineral insulated, copper-sheathed wiring cable (Pyrotenax System 1850 or equal).

D. Class 1 Control Cabling (120VAC Control Circuits, Etc.)
   1. Unless specified otherwise, Class 1 control cabling shall:
      a. Be rated for exposed cable tray installation.
      b. Be plenum rated.
      c. Be UL-rated for the proposed application.

d. Be multi-conductor with overall outer sheath as required by the application. The insulation of each conductor within the overall multi-conductor cable shall be uniquely color-coded. Ground conductors (when provided) within the multi-conductor cable shall have green insulation. Conductors with green insulation shall not be used for conductors other than ground.
e. Utilize copper conductors.
f. Have wire gauge as required to limit voltage drop to acceptable limits determined by the system supplier and to meet all applicable code requirements.
g. Where installed underground, within slab-on-grade or in exterior locations, be rated for wet locations.
h. Where required for specific systems, meet the specific requirements (conductor quantity, wire gauge, insulation type, shielding, etc.) of the system supplier.
i. Be rated for 600V.
j. Be industrial grade.
k. Have stranded conductors.
l. Have sunlight/oil-resistant PVC/Nylon insulation and jacket with ripcord.

2. Control cabling shall be as manufactured by Belden, AlphaWire or General Cable.

E. Fixture Wiring
1. Conductor Types:
a. Type TFFN or XFF.
2. Minimum Sizes:
a. For fixtures up to 300 watts: #16.
b. For fixtures over 300 watts up to 1500 watts: #14.
c. For fixtures over 1500 watts: as required.
d. Conductors to concrete pour fixtures: #12.
3. Fixture wire shall extend only from fixture to first junction, and not over 6 feet, except for concrete pour units.

2.2 WIRE CONNECTIONS:

A. All connector types:
1. Shall be properly rated for the proposed application by UL and per the manufacturer.

B. At Motor Connections (within motor terminal boxes):
1. On Unshielded Wire:
a. Single conductor per phase: shall be made with insulated set screw connectors or 3M 5300 Series 1kV Motor Lead Connections kits with mechanical lugs as required.
b. Multiple conductors per phase: shall be made with insulated mechanical lugs, rated for the associated motor cable types, by Polaris or Ilsco.
2. On Shielded Power Wire:
a. The braided shields and internal grounding conductors of shielded power (not instrumentation) cables shall be grounded at BOTH ends (at VFD/starter and at motor) with a termination kit provided by the cable supplier. This termination kit shall include a connection ring that makes contact around the full circumference of the braided shield, and connects all internal grounds to a common external ground point.

C. Other Dry locations:

1. On Wire larger than #10: shall be made with solderless, non-insulated compression-type connectors meeting requirements of Federal Specification WS-610e for Type II, Class 2 and shall be covered with Scotch #33 electrical tape so that insulation is equal to 150% of conductor insulation.
2. On Wire #10 and smaller: shall be made with one of the following:
   a. Ideal Wing Nuts or equal by 3M .
   b. Ideal Push-In Wire Connectors (for #12 and smaller only).

D. Other Wet/Damp locations:
1. On Wire larger than #10: shall be made with underground/direct-burial, waterproof rated EPDM or TPE-insulated connectors by Ilsco, Burndy or T&B.
2. On Wire #10 and smaller: shall be made with one of the following:
   a. Ideal Weatherproof or Underground Wire Connectors pre-filled with 100% silicone sealant as required by the application.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. All wires and cables shall be installed in conduit unless specifically noted otherwise.

B. All joints and splices on wire shall be made with solderless connectors, and covered so that insulation is equal to conductor insulation.

C. No splices shall be pulled into conduit.

D. No conductor shall be pulled until conduit is cleaned of all foreign matter.

E. Wire and cable shall be neatly formed, bundled and tied in all panelboards, wireways, disconnect switches, pullboxes, junction boxes, cabinets and other similar electrical enclosures.

F. All wires and cables installed in underground or other wet locations shall be rated by the manufacturer for wet locations.

G. Network cabling shall be continuous from endpoint to endpoint and shall not be spliced unless specifically noted otherwise.

H. All conductors/cabling (including spare conductors) shall be properly terminated unless specifically directed otherwise. See above for general termination hardware requirements.

3.2 POWER WIRE AND CABLE INSTALLATION:

A. No power conductor shall be smaller than #12 except where so designated on the drawings or hereinafter specified.

B. Multi-wire lighting branches shall be used as indicated.

C. Where more than three current-carrying conductors are installed in a single raceway or cable, conductors

shall be derated as indicated in NEC Table 310.15(B)(3)(a).

D. Raceways/cables shall generally not be installed exposed to sunlight on roofs unless specifically required. Where raceways or cables are installed exposed to sunlight on roofs, conductors shall be derated with ampacities adjusted per NEC Table 310.15(B)(3)(c).

E. In installing parallel power conductors, it is mandatory that all conductors making up the feeder be exactly the same length, the same size, the same type of conductor with the same insulation. Each group of conductors making up a phase or neutral must be bonded at both ends in an approved manner.

F. In installing overhead main power services, a minimum of 5'-0" of cable per run shall be extended beyond the weatherhead(s) for connection to service drop. Confirm exact requirements with local utility company.

3.3 WIRE CONNECTIONS

A. See Part 2 above for material types.

B. Aluminum Wire Connections:
1. Where aluminum wiring is allowed, connections shall utilize compression fittings, no exceptions (Anderson Versa Crimp or equal).

C. Any stranded wire connection to wiring devices shall be made with crimp type terminals.

D. All electrical connections and terminals shall be tightened according to manufacturer's published torque-tightening values with calibrated torque wrenches as required to clearly indicate final torque value to the contractor. Where manufacturer's torque values are not provided, those specified in UL 486A & 486B shall be used.

E. All connections and connector types shall be installed in strict compliance with all requirements of the connector manufacturer.

F. Under no condition shall the specified conductors be connected to terminals rated less than 75°C. Where conductors sized #1 or smaller are shown to be terminated at equipment and the terminals of that equipment are rated for less than 75°C, contractor shall install junction box near equipment to capture the specified conductors, splice with compression connections (rated for a least 75°C) and extend conductors with ampacity rating as required by NEC (based on terminal temperature rating) to equipment terminals. The length of the conductors to be terminated shall be as directed by the AHJ but not less than 48 inches.

3.4 LOW VOLTAGE (LESS THAN 50V) CONTROL AND NETWORK CABLE INSTALLATION:

A. All wires and cables shall be installed in conduit unless specifically noted otherwise. Low voltage control and/or network cabling located within concealed, accessible ceiling spaces (such as above lay-in ceilings) may be run without conduit if the following requirements are met:
1. Cabling shall be plenum-rated, multi-conductor.
2. Cabling shall be supported by cable tray or with J-hook supports on intervals not to exceed 5'-0" on center. Cabling shall be supported solely from the cable tray or j-hooks supported from the building structure, without using piping, ductwork, conduit or other items as supports.

3. Cabling shall be properly bundled with plenum-rated Velcro straps on intervals not to exceed 30" on center.
4. Properly-sized conduit(s) shall be provided wherever cabling enters an inaccessible or exposed area (such as above gyp board ceilings or through walls). End bushings shall be provided on both ends of all raceway terminations. All fire/smoke barrier penetrations shall be made in accordance with a U.L. listed assembly.

3.5 CIRCUITS AND BRANCH CIRCUITS

A. Outlets shall be connected to branch circuits as indicated on drawings by circuit number adjacent to outlet symbols, and no more outlets than are indicated shall be connected to a circuit.

3.6 LABELING AND COLOR CODING OF WIRE AND CABLE

A. Refer to Specification Section 26 05 53 for all labeling requirements.

B. A color coding system as listed below shall be followed throughout the network of branch power circuits as follows:

PHASE	120/208/240/ COLOR	120/240 HIGH LEG DELTA COLOR	277/480 VOLT COLOR
A	BLACK	BLACK	BROWN
B	RED	ORANGE (FOR HI-LEG)	ORANGE
C	BLUE	BLUE	YELLOW
NEUTRAL	WHITE	WHITE	GRAY
GROUND	GREEN	GREEN	GREEN

C. Where dedicated neutrals are installed for multi-wire branch circuits, the neutral conductors shall be color coded as follows:

PHASE	120/208/240/ COLOR	120/240 HIGH LEG DELTA COLOR	277/480 VOLT COLOR
NEUTRAL A	WHITE W/ BLACK TRACER	WHITE W/ BLACK TRACER	GRAY W/ BROWN TRACER
NEUTRAL B	WHITE W/ RED TRACER	WHITE W/ ORANGE TRACER (FOR HI-LEG NEUTRAL)	GRAY W/ ORANGE TRACER
NEUTRAL C	WHITE W/ BLUE TRACER	WHITE W/ BLUE TRACER	GRAY W/ YELLOW TRACER

D. Control Conductors: Shall be color coded by use of colored "tracers". No control circuit shall contain two identical conductors. For example, a set of five (5) control conductors for a pushbutton station represents one (1) control circuit which would require five (5) uniquely-colored control conductors.

3.7 TESTING

A. The insulation resistance of all feeder conductors (feeding electrical distribution equipment such as switchboards, panelboards, transfer switches, transformers, etc.) shall be tested at the load side of the feeder breaker with a 1000-volt DC Megger Tester prior to energization or final termination. Any feeder conductor with an insulation resistance less than the recommended minimums in the latest version of NETA Acceptance Testing Specification ("ATS") standard shall be replaced by the contractor at the contractor's expense. All final test results shall be clearly documented (with date, time, feeder, results, test equipment, etc.), and the final test results shall be submitted to the design team for review.

END OF SECTION 26 05 19

SECTION 26 05 26

GROUNDING

PART 1 - GENERAL

1.1 GENERAL

A. THE WORK UNDER THIS SECTION INCLUDES BUT IS NOT LIMITED TO GROUNDING OF THE FOLLOWING:
1. Service Equipment.
2. Transformers.
3. Non-current carrying conductive surfaces of equipment.
4. Metal Buildings.
5. Structures.
6. Other Equipment.

1.2 GENERAL REQUIREMENTS

A. All equipment, building steel, and main service shall be effectively and permanently grounded with a conductor cross section as required by the National Electrical Code and of capacity sufficient to insure continued effectiveness of the ground connections for fault current. Ground conductors shall be as short and straight as possible, protected from mechanical injury and, if practicable, without splice or joint.

B. All grounding connections shall be installed in accordance with the National Electrical Code and all local codes and requirements. Such codes shall be considered minimum requirements and the installation of the grounding system shall insure freedom from dangerous shock voltage exposure and provide a low impedance ground fault path to permit proper operation of overcurrent and ground fault protective devices.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. All grounding conductors shall be insulated with green colored, 600 volt insulation unless noted otherwise.

B. Motors having power supplied by single conductor wire in conduit shall be grounded through the conduit system. Flexible conduit shall be “jumpered” by an appropriate bonding conductor.

2.2 GROUNDING ELECTRODES

A. Grounding electrodes shall be copper-clad steel rods 3/4 inch in diameter and ten feet long. Where longer electrodes are necessary to reduce the ground resistance, Contractor shall provide sectional rods, connectors, drive heads, etc.

2.3 CONNECTIONS

A. All conductor-to-conductor, conductor-to-ground rod, conductor-to-structure, conductor-to-fence

connections of #6 and larger sized conductors and underground ground connections shall be permanent exothermic welded connections (Cadweld or equal) unless otherwise noted on applicable drawings.

B. Connections to equipment shall be by bolted compression type lugs (except for motors). When the conductor is #6 and larger, the lug shall be joined to the conductor by an exothermic weld (Cadweld or equal).

C. Motors to be grounded by the grounding conductors run with the power conductors shall have a split-post grounding stud installed in the connection box.

D. Each cast pull box or junction box shall have a ground lug, connected to largest ground conductor to enter box.

E. Ground connections at conduit terminations shall be made by approved grounding bushings (see Raceways Specification Section for additional requirements).

2.4 MANUFACTURERS

A. Conduit clamps and connectors shall be manufactured by Raco, OZ., or Ercon.

B. Lugs shall be as manufactured by Square “D”, Burndy, or T and B.

C. Exothermic weld connections shall be as manufactured by Cadweld, or approved equal.

D. Ground rods shall be as manufactured by Joslyn or McGraw Edison.

E. Split post grounding shall be as manufactured by Burndy or T and B.

PART 3 - EXECUTION

3.1 MAIN SERVICE GROUND

A. The main service grounding electrode system shall consist of the following items bonded together by the grounding electrode conductor:
1. The main underground cold water pipe (metal).
2. The metal frame of the building.
3. Driven ground rods. Ground rods shall be embedded at the lowest point in the building and below the permanent moisture level. Ground rods shall be spaced a minimum of ten (10) feet apart and connected in parallel until resistance to ground does not exceed five (5) ohms.

B. The grounding electrode system shall be connected to the grounded conductor (neutral) on the supply side of the service disconnecting means by a grounding electrode conductor not smaller than that shown in Table 250.66 of the N.E.C. The main service equipment grounding conductor shall be connected to the grounding conductor on the supply side of the service disconnecting means in accordance with Table 250.122 of the N.E.C. for the ampere rating of the service entrance equipment. Where in a service entrance switchboard, the equipment grounding conductor shall not be less than 25% of the main bus rating. These connections shall be made inside the service entrance equipment enclosure.

3.2 TRANSFORMER GROUNDS

A. Dry type insulation transformers with a grounded conductor in the secondary shall be grounded in accordance with N.E.C. Section 250-30.

3.3 EXPOSED NON-CURRENT-CARRYING METAL PARTS

A. General: Ground connections to equipment or devices shall be made as close to the current carrying parts as possible, that is, to the main frame rather than supporting structures, bases or shields. Grounding connections shall be made only to dry surfaces that are clean and dry. Steel surfaces shall be ground or filed to remove all scales, rust, grease, and dirt. Copper and galvanized steel shall be cleaned to remove oxide before making welds or connections. Code size ground conductors shall be run in all power conduits and properly terminated at each end.

B. Ground conductors shall be routed as straight as possible. Where possible, ground conductors shall be routed such as to avoid bends exceeding 90 degrees or with a radius of less than 8".

C. Motors: Exposed non-current-carrying metal parts, shall be grounded by a grounding conductor either run with power conductors, and/or separate grounding conductors. Drawings will show method(s) to be used. The ground conductors with all motor conductors shall be connected to the ground buss in the motor connection box. Jumper connections shall be installed between frames and rigid conduit for equipment having flexible conduit connections (sealtight). All AC motor grounds shall provide a low impedance path to ground.

D. Raceways & boxes: All raceways, conduits, armored or shielded cable and all exposed non-current carrying metal parts shall be grounded. Such items shall be bonded together and permanently grounded to the equipment ground buss. Metallic conduits shall be connected by grounding or clamps to ground buss. Flexible "jumpers" shall be provided around all raceway expansion joints. Bonding straps for steel conduit shall be copper. Jumper connections shall be provided to effectively ground all sections or rigid conduit connected into plastic pipe. No metallic conduit shall be left ungrounded. In conduit systems interrupted by junction or switch boxes where locknuts and bushings are used to secure the conduit in the box, the sections of conduit and box must be bonded together. If conduit, couplings or fittings have a protective coating or non-conductive material, such as enamel, such coating must be thoroughly removed from threads of both couplings and conduit and the surface of conduit or fitting where the ground clamp is secured.

E. Enclosures: Metal conduits entering free standing motor control centers, switchboards or other free standing equipment shall be grounded by bare conductors and approved clamp. Any conduits entering low voltage (480 volts or below) equipment through sheet metal enclosure and effectively grounded to enclosure by double locknut or hub need not be otherwise bonded.

F. Equipment: In addition to equipment grounding provisions mandated by code requirements, additional equipment grounding provisions (including local ground rods, connections, etc.) shall be provided by the contractor as directed by equipment suppliers.

G. Both ends of ground busses in motor control centers, switchboards, etc., shall be separately connected to the main ground buss to form two separate paths to ground.

H. Fences and Grills: Fences and metal grills around equipment carrying voltage above 500 volts between phases shall be bonded together and to ground. Fences and grill work shall be grounded at every post,

column, or support, and on each side of every gate.

3.4 ACCEPTANCE DOCUMENTATION AND TESTING

A. Contractor shall take and store photographs of all underground grounding system connections prior to burial of connections, for review by Engineer.

B. Upon completion of work, the entire ground system shall be shown to be in perfect working condition, in accordance with the intent of the Specifications.

C. Contractor shall measure the resistance between the main ground bonding jumper to true earth ground using the Fall of Potential method as described by ANSI/IEEE Standard 81 (“Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of an Earth System”). If the measured value is greater than five ohms, additional grounding electrodes shall be installed as described in Part 3.1 above. The final ground resistance value shall be submitted in writing, and documented via picture of the meter reading from the Fall of Potential test, to the Architect prior to the final observation, and shall be included in final O&M documentation.

END OF SECTION 26 05 26

SECTION 26 05 33

RACEWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. THE WORK UNDER THIS SECTION INCLUDES BUT IS NOT LIMITED TO THE FOLLOWING:
1. Conduits
2. Conduit Fittings
3. Couplings & Connectors
4. Bushings
5. Raceway Hardware, Conduit Clamps & Supports
6. Watertight Entrance Seal Devices

PART 2 - PRODUCTS

2.1 CONDUITS

A. Rigid Galvanized Steel and I.M.C.:
1. Shall be galvanized outside and inside by hot dipping.
2. Shall be as manufactured by Republic, Wheatland, Triangle, Pittsburg Standard, Youngstown, Allied or equal.

B. E.M.T.:
1. Shall be Electro-Galvanized.
2. Shall be as manufactured by Republic, Wheatland, Triangle, Pittsburg Standard, Youngstown, Allied or equal.

C. Rigid Aluminum:
1. Shall be manufactured of 6063 Alloy, T-1 temper.
2. Shall be as manufactured by Republic, Wheatland, Triangle, Pittsburg Standard, Youngstown, Allied or equal.

D. Schedule 40 and 80 PVC:
1. Shall be composed of polyvinyl chloride and shall be U.L. rated type 40 or 80 for use with 90 degree rated conductors. Conduit shall conform to NEMA Standards and applicable sections of N.E.C.
2. The conduit manufacturer shall have had a minimum of 5 years experience in the manufacture of the products. Non-metallic raceways shall be as manufactured by Carlon, Triangle, Can-Tex, Allied or equal.

E. HDPE Innerduct
1. Shall be composed high density polyethylene and shall be orange in color, unless noted otherwise.
2. Shall be corrugated unless noted otherwise.
3. Shall be manufactured by Carlon, Ipex or equal.

F. Flexible Metallic Conduit:
   1. Shall be continuous spiral wound and interlocked galvanized material, code approved for grounding.

G. Liquidtight Flexible Metallic Conduit:
   1. Shall be galvanized steel-core sealtite, code approved for grounding.
   2. Shall have an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core.
   3. Shall be as manufactured by Electric-Flex, Anaconda or equal.

2.2 FITTINGS, COUPLINGS & CONNECTORS

A. Rigid Galvanized Steel and I.M.C. couplings and connectors shall be standard threaded type, galvanized outside and inside by hot dipping. Threadless and clamp type are not acceptable. Couplings/connectors shall be as manufactured by Raco, Efcor, or Appleton or equal.

B. All rain tight connectors shall be threaded Myers or approved equal, rated for outdoor application.

C. E.M.T. couplings and connectors shall be set screw, or steel compression type. All couplings and connectors shall be 720B, 730, 750B, or 760 series of Efcor or equal series of Raco. Pressure indented type connectors or cast metal will not be approved for any location. E.M.T. couplings and connectors shall be as manufactured by O-Z/Gedney, T&B, Efcor, Raco, Midwest or equal. E.M.T. fittings, couplings and connectors located within concrete (where allowed) shall be compression type and shall be adequately sealed with tape to ensure a concrete-tight seal.

D. Rigid Aluminum couplings and connectors shall be standard threaded type, of the same alloy as the associated conduit. Threadless and clamp type are not acceptable. Fittings shall be as manufactured by Thomas & Betts, Crouse-Hinds, Appleton, Pyle-National or equal.

E. All PVC couplings, adapters, end bells, reducers, etc., shall be of same material as conduit.

F. Liquidtight Flexible Metallic Conduit connectors shall be liquidtight with insulating throat or end bushing, designed for application with Liquidtight Flexible Metallic Conduit. Fittings shall be as manufactured by Efcor, Raco, Midwest or equal.

G. All LB unilets sizes 1 ¼" or larger shall have rollers.

H. Miscellaneous conduit fittings shall be as manufactured by Appleton, Crouse-Hinds, Pyle-National, Russell & Stoll or equal.

2.3 BUSHINGS

A. All non-grounding rigid bushings 1-1/4" and larger shall be the insulating type (O-Z/Gedney type "BB" or equal by T&B, Midwest Electric or Penn Union).

B. All non-grounding rigid bushings 1" and smaller shall be threaded malleable iron with integral noncombustible insulator rated for 150°C. Non-grounding rigid conduit bushings shall be O-Z/Gedney type "B" or equal by T&B, Midwest Electric or Penn Union.

C. All grounding rigid bushings shall be threaded malleable iron with integral noncombustible insulator rated for 150°C. All grounding rigid conduit bushings shall be O-Z/Gedney type "BLG" or equal by T&B, Midwest Electric or Penn Union.

2.4 HARDWARE, CONDUIT CLAMPS AND SUPPORTS

A. All hardware such as expansion shields, machine screws, toggle bolts, "U" or "J" bolts, machine bolts, conduit clamps and supports shall be of corrosion resistant materials (stainless steel, aluminum, galvanized or plated steel, or other approved materials).

B. Hardware in contact with aluminum handrails, plates or structural members and all hardware in exterior, wet or corrosive areas shall be type 316 stainless steel or aluminum (with bitumastic paint coating to isolate aluminum from contact with concrete where necessary) unless specifically noted otherwise.

C. Supports in exterior, wet or corrosive locations shall be type 316 stainless steel or aluminum (with bitumastic paint coating to isolate aluminum from contact with concrete where necessary) unless specifically noted otherwise.

D. Supports in extremely corrosive environments (such as chlorine or fluoride storage rooms) shall be PVC-Coated steel unless specifically noted otherwise.

E. Hardware and conduit clamps shall be as manufactured by Efcor, Steel City, G.A., Tinnerman or equal.

2.5 WATERTIGHT ENTRANCE SEAL DEVICES

A. For new construction, seal devices shall consist of oversized sleeve and malleable iron body with sealing rings, pressure rings, sealing grommets and pressure clamps as required (O-Z/Gedney type FSK/WSK or equal).

B. For cored-hole applications, seal devices shall consist of assembled dual pressure disks with neoprene sealing rings and membrane clamps as required (O-Z/Gedney type CSM or equal).

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Minimum Diameter: 3/4-inch.

B. Raceway Type: Raceway types shall be as specified below, unless indicated otherwise on drawings:
1. Exterior, Exposed: Rigid Galvanized Steel or I.M.C. unless otherwise noted.
2. Other Exterior (Concrete-Encased or Direct Earth Buried): Schedule 40 PVC. PVC conduit shall convert to metallic conduit prior to exiting concrete-encasement or direct earth burial. See "transition" items below for additional requirements. Conduits shall be left exposed until after Architect's observation.
3. Interior, Exposed:
   a. Hazardous Locations: Rigid Galvanized Steel .
   b. Wet Locations (including, but not limited to, Pump Rooms, Wet Wells, Underground Vaults, and other similar locations): Rigid Galvanized Steel or I.M.C. .

c. Dry Locations Where Subject to Mechanical Damage (including, but not limited to, below 10'-0" A.F.F. in shop, storage, warehouse and other similar areas): Rigid Galvanized Steel or I.M.C..
d. Extremely Corrosive Locations (Chlorine Storage Rooms, Fluoride Storage Rooms and other similar areas): Schedule 80 PVC.
e. Other Dry Locations: E.M.T.

4. Interior, Concealed:
   a. Embedded inside Poured Concrete Walls, Ceilings or Floors, with a minimum of 2" of concrete between finished surface and outer wall of conduit on all sides, where no anchor bolts, screws or other similar items will be installed: Schedule 40 PVC. PVC conduit shall convert to metallic conduit (exact type as specified elsewhere within this section) prior to exiting poured concrete-encasement of wall, ceiling, floor or ductbank. See "transition" items below for additional requirements.
   b. Other Raceways Embedded inside Poured Concrete Walls, Ceilings or Floors (not meeting requirements above): Rigid Galvanized Steel or I.M.C. (coated with two (2) spiral-wrapped layers of 3M Scotchrap 50 PVC tape or two coats of asphaltum paint where below grade or within concrete).
   c. Other Raceways: E.M.T.
5. Terminations at motors, transformers and other equipment which has moving or vibrating parts:
   a. Exterior or Wet Locations (including, but not limited to, Pump Rooms, Wet Wells, Underground Vaults, and other similar locations): Liquidtight Flexible Metallic Conduit (shall generally not exceed 24 inches in length) with watertight fittings.
   b. Dry, Interior Locations: Flexible Metallic Conduit (shall generally not exceed 24 inches in length).
6. Terminations at fixtures mounted in grid-type ceilings:
   a. Flexible Metallic Conduit or MC cabling (shall generally not exceed 72 inches in length and shall run from junction box to fixture, not from fixture to fixture).
7. Transition from underground or concrete-encased to exposed:
   a. Convert PVC to Rigid Galvanized Steel (coated with two (2) spiral-wrapped layers of 3M Scotchrap 50 PVC tape or two coats of asphaltum paint where below grade or within concrete) utilizing Rigid Galvanized Steel 90 degree bends (and vertical conduits as required by application) prior to exiting concrete/grade (except at outdoor pull boxes and under freestanding electrical equipment, where terminations shall be by PVC end bells installed flush with top of slab). Exposed portions of these coated conduits shall extend a minimum of 6" above floor level, and shall be installed at uniform heights.

3.2 RACEWAY INSTALLATION

A. General:
1. Follow methods which are appropriate and approved for the location and conditions involved. Where not otherwise shown, specified, or approved in a particular case, run all wiring concealed.
2. Where conduit crosses a structural expansion joint an approved conduit expansion fitting shall be installed.
3. A non-conductive polypropylene pull string, properly tied/secured at either end, shall be installed in all empty conduits.
4. Metal conduit field-cuts shall be cut square with a hacksaw and the ends reamed after threading.
5. PVC conduit field-cuts shall be made with hacksaw, and ends shall be deburred.
6. All PVC joints shall be made as follows:

a. Clean the outside of the conduit to depth of the socket, and the inside of socket with an approved cleaner.
b. Apply solvent cement as recommended by the conduit manufacturer to the interior of the socket and exterior of conduit, making sure to coat all surfaces to be joined.
c. Insert conduit into the socket and rotate 1/4 to 1/2 turn and allow to dry.

7. All metallic conduit installed below grade or within concrete shall be coated with two (2) spiral-wrapped layers of 3M Scotchrap 50 PVC tape or two coats of asphaltum paint prior to installation.
8. Install ground wire sized per N.E.C. Table 250.122 in all conduits.
9. Use of running threads is absolutely prohibited. Conduit shall be jointed with approved threaded conduit couplings. Threadless and clamp type not acceptable.
10. Conduits shall be sized in accordance with latest National Electrical Code except when size shown on drawings. 1/2-inch conduit shall not contain conductors larger than No. 12 or more than four (4) No. 12 conductors.
11. Exposed, field-cut threads on all metal conduits shall be painted with zinc primer (for Galvanized Rigid or I.M.C.) .

B. Routing/Locating:
1. Exposed conduit runs shall be run level and plumb and shall, on interior of buildings, be run parallel and/or at right angles to building walls and/or partitions.
2. Conduit with an external diameter larger than 1/3 the thickness of a concrete slab shall not be placed in the slab. Conduits in slab shall not be spaced closer than 3 diameters on center.
3. Conduit run in ceiling spaces shall be run as high as possible, all at same level, and shall be supported from building structure. Do not support conduit from any other installation.
4. Conduit run within exterior CMU, concrete or other similar walls shall be run within the CMU cells / concrete structure / etc. Conduits shall not be run on the outside surface of CMU cells / concrete structure / etc. underneath exterior veneers / etc., which could cause a thermal break in the wall insulation or a future water intrusion problem.
5. Install conduit runs to avoid proximity to steam or hot water pipes. In no place shall a conduit be run within 6” of such pipes except where crossing is unavoidable, then conduit shall be kept at least 3” from the covering of the pipe crossed.
6. Before installing raceways for motors, HVAC equipment and other fixed equipment, check location of all equipment connections/terminal boxes with equipment supplier and locate and arrange raceways appropriately.
7. A minimum of 12” of clearance (or more as required by associated utility companies) shall be provided between the finished lines of exterior, underground conduit runs and exterior, underground utilities (gas, water, sewer, etc.).
8. Where any portion of raceway is installed in a wet environment (such as below grade) and located at a higher elevation than the raceway termination point in a dry environment, install watertight compound inside raceway at termination around cabling to prevent transfer of water through conduit system. Watertight compound shall be rated for the potential water head pressure, based on the assumption that ground water level would be at grade level.

C. Bends:
1. Do not make bends (in any raceway, including flexible conduits) that exceed allowable conductor bending radius of cable to be installed or that significantly restrict conductor flexibility.
2. All bends within concrete-encased ductbanks installed in exterior locations shall be long radius bends (24” minimum bending radius – varies with conduit diameter).

3. Where numerous exposed bends or grouped together, all bends shall be parallel, with same center and shall be similar in appearance
4. All PVC elbows, bends, etc., shall be either factory bends or made with an approved heat bender.

D. Support:
1. Anchor conduit securely in place by means of approved conduit clamps, hangers, supports and fastenings. Arrangement and methods of fastening all conduits shall be subject to Engineer's direction and approval. All conduits shall be rigidly supported (wire supports may not be used in any location). Use only approved clamps on exposed conduit.
2. Conduit in riser shafts shall be supported at each floor level by approved clamp hangers.
3. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameters of conduits.
4. Where installed in seismic zones, suspended raceways shall be braced in two (2) directions as required to prevent swaying and excessive movement.
5. Raceways installed on top of flat roofing shall be supported a minimum of 3 ½" above roof with rubber block supports (Cooper B-Line Dura-Blok or equal). Installation shall be in strict accordance with support manufacturer's instructions and recommendations.

E. Terminations:
1. All conduit connections to sheet metal cabinets or enclosures located in exterior or wet locations shall terminate by use of rain tight (Meyers) hubs.
2. Where rigid or I.M.C. conduits enter sheet metal boxes, they shall be secured by approved lock nuts and bushings.
3. Where metal conduits enter outdoor pull boxes, manholes, under freestanding electrical equipment or other locations where direct metal-to-metal contact does not exist between enclosure and conduit, grounding bushings shall be installed. Each grounding bushing shall be connected to the enclosure ground and all other grounding bushings with properly sized grounding conductors.
4. Where E.M.T. enters sheet metal boxes they shall be secured in place with approved insulating fittings.
5. Where PVC enters outdoor pull boxes, manholes or under freestanding electrical equipment, PVC end bells shall be installed.
6. Contractor shall be responsible for coordinating required conduit sizes with equipment hubs/conduit entry provisions (such as at motor tap boxes) prior to installation of conduit systems. Contractor shall field adjust final conduit sizes at terminations where so required (only as allowed by code) from those indicated on plans to coordinate with equipment hubs/conduit entry provisions.
7. Where conduit terminates in free air such that associated cabling/circuitry becomes exposed (such as at cable trays, etc.), conduit shall generally terminate in a horizontal orientation (to prevent dust/debris/etc. from entering conduit system). Where vertical conduit termination is necessary, the termination shall be provided with cord-grip conduit terminations to seal the conduit system.
8. Conduit ends shall be carefully plugged during construction.
9. Permanent, removable caps or plugs shall be installed on each end of all empty raceways with fittings listed to prevent water and other foreign matter from entering the conduit system.

F. Penetrations:
1. All fire/smoke barrier penetrations shall be made in accordance with a U.L. listed assembly. Refer to drawings and other specifications for additional requirements.

2. All penetrations shall be at right angles unless shown otherwise.
3. Structural members (including footings and beams) shall not be notched or penetrated for the installation of electrical raceways unless noted otherwise without specific approval of the structural engineer.
4. Dry-packed non-shrink grout or watertight seal devices shall be used to seal openings around conduits at all penetrations through concrete walls, ceilings or aboveground floors.
5. All raceways entering structures, or where water is otherwise capable of entering equipment/devices through the raceway system, shall be sealed (at the first box or outlet) with foam duct sealant to prevent the entrance of gases or liquids from one area to another or into equipment/devices.
    a. Where the elevation of the raceway penetration (into the structure) is no more than 15' below the other (higher) end of the same raceway, Polywater FST sealant (rated to hold back up to 22' of continuous water head pressure), or pre-approved equal, shall be used.
    b. Where the elevation of the raceway penetration (into the structure) is between 15' and 75' below the other (higher) end of the same raceway, Polywater PHRD Custom Mechanical Seals (rated to hold back up to 36psi or 83' of continuous water head pressure), or pre-approved equal, shall be used.
    c. Where the elevation of the raceway penetration (into the structure) is more than 75' below the other (higher) end of the same raceway, the contractor shall propose a custom solution designed to hold back or to drain the possible water within the associated raceway. Submittals shall be provided to the engineer for review/approval, including a summary of the anticipated elevations/PSIs, details of the proposed installation, cut-sheets of devices/materials, etc.
6. Additionally, where necessary to ensure that water does not enter equipment/devices through the raceway system (where raceways extend to equipment/devices from wet areas), junction boxes with drain assemblies in bottom shall be located at low point of raceway system near equipment/devices (to drain water out of raceway system before it enters equipment/devices). Contractors shall provide drains in raceway systems where so necessary to prevent water entry into equipment/devices.
7. All raceways passing through concrete roofs or membrane-waterproofed walls or floors shall be provided with watertight seals as follows:
    a. Where ducts are concrete encased on one side: Install watertight entrance seal device on the accessible side of roof/wall/floor as directed by equipment manufacturer.
    b. Where ducts are accessible on both sides: Install watertight entrance seal device on each side of roof/wall/floor as directed by equipment manufacturer.
8. All raceways passing through walls of rooms containing/storing noxious chemicals (chlorine, ammonia, etc.) or through hazardous locations shall be sealed with conduit seals (Crouse-Hinds type EYS or equal).
9. All raceways terminating into electrical enclosures/devices/panels/etc. located in hazardous locations shall be sealed with conduit seals (Crouse-Hinds type EYS, EZS or equal) within 18" of the termination.

G. Exterior Electrical Ductbanks:
1. Where exterior electrical concrete-encased ductbanks are indicated on drawings, conduit runs between buildings or structures shall be grouped in concrete-encased ductbanks as follows:
    a. A minimum of 3" of concrete shall encase each side of all ductbanks.

b. A minimum of 1 ½" of separation shall be provided between each conduit within ductbanks. PVC spacers shall be installed at the necessary intervals prior to placement of concrete to maintain the required spacing and to prevent bending or displacement of the conduits.
c. Top of concrete shall be a minimum of 30" below grade. A continuous magnetic marking tape shall be buried directly above each ductbank, 12" below grade.
d. Exact routing of ductbanks shall be field verified and shall be modified as necessary to avoid obstruction or conflicts.
e. Underground electrical raceways shall be installed to meet the minimum cover requirements listed in NEC Table 300.5. Refer to drawings for more stringent requirements.

END OF SECTION 26 05 33

SECTION 26 05 34

OUTLET BOXES, JUNCTION BOXES, WIREWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Outlet and Junction Boxes

B. Pull Boxes

C. Wireways

PART 2 - PRODUCTS

2.1 OUTLET BOXES & JUNCTION BOXES (THROUGH 4-11/16")

A. Sheet Metal: Shall be standard type with knockouts made of hot dipped galvanized steel as manufactured by Steel City, Raco, Appleton, Bowers or equal.

B. Cast: Shall be type FS, FD, JB, GS, or SEH as required for application as manufactured by O-Z/Gedney, Appleton, or equal.

C. Nonmetallic: Shall be type Polycarbonate/ABS construction as required for application with non-metallic quick-release latches as manufactured by Hoffman, O-Z/Gedney, Appleton, or equal.

2.2 JUNCTION AND PULL BOXES (LARGER THAN 4-11/16")

A. Oil-Tight JIC: Shall be Hoffman Type CH box or approved equal.

B. Galvanized Cast Iron or Cast Aluminum: Shall be O-Z/Gedney or approved equal.

C. Stainless Steel: Shall be as manufactured by O-Z/Gedney, Hoffman or approved equal. Boxes shall have continuous hinges, seamless foam-in-place gaskets and screw-down clamps.

D. Nonmetallic: Shall be type Polycarbonate/ABS construction as required for application with non-metallic quick-release latches as manufactured by Hoffman, O-Z/Gedney, Appleton, or equal. Boxes shall have hinged covers and screw-down clamps.

E. Wireways: Shall be standard manufacturer's item as manufactured by Hoffman, Square "D", Burns, B & C or equal. Wireways shall have hinged covers and screw-down clamps.

F. Pre-cast Polymer Concrete Below-Grade Hand Holes & Pull Boxes:
   1. Enclosures, boxes and cover are required to be UL Listed and conform to all test provisions of ANSI/SCTE 77 "Specifications For Underground Enclosure Integrity" for Tier 15 applications (15,000lb design load and 22,500lb test load) unless noted otherwise.
   2. All covers shall have a minimum coefficient of friction of 0.05 in accordance with ASTM C1028 and the corresponding Tier level shall be embossed on the top surface.

3. Cover shall be bolt-down include factory-labeling to read “Electric”, “Communications” or other as directed.
4. Hardware shall be stainless steel.
5. Shall be Quazite PG/LG Style or approved equal.

G. Galvanized Cast Iron Below-Grade Pull Boxes:
1. Enclosures, boxes and cover are required to conform to AASHTO H-20 requirements for deliberate vehicular traffic applications unless noted otherwise.
2. Cover shall be checkered, bolt-down include factory-labeling to read “Electric”, “Communications” or other as directed.
3. Hardware shall be stainless steel.
4. Shall be furnished with grounding kit.
5. Shall be O-Z/Gedney Type YR or approved equal.
a.

PART 3 - EXECUTION

3.1 APPLICATION

A. General
1. All boxes and wireways shall be of sufficient size to provide free space for all enclosed conductors per NEC requirements. Fill calculations shall be performed by contractor per NEC requirements.

B. Outlet Boxes & Junction Boxes (through 4-11/16”)
1. Sheet metal boxes shall be used on concealed work in ceiling or walls and exposed work in dry, interior locations
a. Exception: Where exposed and installed within finished/public spaces such as offices, corridors, lobbies, etc., cast boxes shall be used for wiring device outlets. Cast boxes are not required in back-of-house areas such as electrical rooms, mechanical rooms, etc. .
2. Cast boxes shall be used wherever Rigid or I.M.C. conduits are installed.
3. All boxes installed in extremely corrosive areas (such as chlorine and fluoride storage rooms) where non-metallic raceways are used shall be non-metallic.
4. Except when located in exposed concrete block, switch and receptacle boxes shall be 4" square for single gang installation. Appropriate gang boxes shall be used for mounting ganged switches.
5. When installed in exposed concrete block, switch and receptacle boxes shall be square type designed for exposed block installation.
6. Ceiling outlet boxes shall be 4" octagon 1-1/2" deep or larger required due to number of wires.
7. Boxes installed in hazardous locations shall be explosion-proof rated for the associated application, constructed of copper-free cast aluminum.

C. Junction & Pull Boxes (larger than 4-11/16”)
1. For all below grade exterior use and elsewhere as shown:
a. In areas subject to future vehicular traffic: shall be galvanized cast iron (rated AASHTO H-20 Loading unless noted otherwise).
b. In areas not subject to vehicular traffic: shall be galvanized cast iron or pre-cast polymer concrete (rated for Tier 15 Loading unless noted otherwise).

2. All boxes installed exposed in exterior or wet areas shall be powder-coated galvanized steel (NEMA 3R).
3. All boxes installed exposed in corrosive areas shall be stainless steel (NEMA 4X).
4. All boxes installed in extremely corrosive areas (such as chlorine and fluoride storage rooms) where non-metallic raceways are used shall be non-metallic.
5. Boxes installed in hazardous locations shall be explosion-proof rated for the associated application, constructed of copper-free cast aluminum.
6. All others shall be oil tight JIC box not less than 16 gauge.

3.2 INSTALLATION

A. General
1. All boxes and wireways shall be securely anchored.
2. All boxes shall be properly sealed and protected during construction and shall be cleaned of all foreign matter before conductors are installed.
3. All boxes and wireways shall be readily accessible. Contractor shall be responsible for furnishing and installing access panels per architect's specifications. Locations shall be as directed by the architect as required to make boxes, wireways, electrical connections, etc. accessible where above gypsum board ceilings or in other similar locations.
4. All metallic boxes and wireways shall be properly grounded.
5. Refer to Specification Section 26 05 53 for identification requirements.

B. Outlet Boxes & Junction Boxes (through 4-11/16")
1. Boxes shall be provided with approved 3/8" fixture studs were required.
2. Recessed boxes for wiring devices, surface fixtures, or connections, shall be set so that the edge of cover comes flush with finished surface.
3. There shall be no more knockouts opened in any sheet metal box than actually used.
4. Any unused opening in cast boxes shall be plugged.
5. Back to back boxes to be staggered at least 3 inches.
6. Under no circumstances shall through-the-wall boxes be used.

C. Junction & Pull Boxes (larger than 4-11/16")
1. Pull boxes shall be installed as indicated on plans and/or as required due to number of bends, distance or pulling conditions.
2. Boxes to be imbedded in concrete shall be properly leveled and anchored in place before the concrete is poured.
3. All pull boxes and/or junction boxes installed exterior below grade, shall have their tops a minimum of 1-1/2 inches above surrounding grade and sloped so that water will not stand on lid. A positive drain shall be installed, to prevent water accumulation inside.
4. Above grade pull boxes shall be installed on concrete anchor bases as shown on Plans.

D. Wireways and/or wall-mounted equipment
1. Mount each wireway to channels of the same metal type as the wireway.
2. Conductors serving a wireway shall be extended without reduction in size, for the entire length of the wireway. Tap-offs to switches and other items served by the wireway shall be made with ILSCO type GTA with GTC cap.

END OF SECTION 26 05 34

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Wire and cable identification.

B. Pullbox & Junction Box Identification

C. Electrical distribution & utilization equipment identification.

D. Emergency and Standby Power receptacle identification.

PART 2 - PRODUCTS

2.1 WIRE AND CABLE IDENTIFICATION

A. Intermediate Locations:
1. Wires and cable labels shall be white, thermal transfer, halogen-free, flame-retardant marker plates (sized to accommodate three lines of text) permanently affixed to the associated cable with UV-resistant plastic wire ties. Labels shall be Panduit #M200X/300X series or equal.

B. Circuit/Cable Termination Locations:
1. Wires and cable labels shall be non-ferrous identifying tags or pressure sensitive labels unless noted otherwise.

2.2 ELECTRICAL DISTRIBUTION & UTILIZATION EQUIPMENT IDENTIFICATION

A. Labels on electrical distribution & utilization equipment shall be black-on-white engraved Bakelite nameplates permanently affixed to the equipment with rivets or silicone adhesive unless noted otherwise.

B. Labels on electrical distribution equipment fed from emergency or legally-required standby sources (such as emergency generators) shall be white-on-red engraved Bakelite nameplates permanently affixed to the equipment with rivets or silicone adhesive.

2.3 EMERGENCY AND STANDBY POWER RECEPTACLE IDENTIFICATION

A. Receptacles fed from emergency or standby power sources (such as emergency generators) shall be provided with factory-marked engraved coverplates as follows:
1. Emergency System source: Red engraved lettering to read “EMERGENCY”.
2. Legally-Required or Optional Standby Generator source:
   a. If only part of facility is fed with generator backup: Black engraved lettering to read “FED FROM GENERATOR”.
   b. If entire facility is fed with generator backup: No “….GENERATOR…” label required.

PART 3 - EXECUTION

3.1 GENERAL

A. Any proposed deviation in identification methods and materials from those described herein shall be submitted to Architect for review and comment prior to installation.

B. Contractor shall provide all labeling or identification required by applicable local, state and national codes. These specifications do not intend to itemize all code-required labeling or identification requirements.

C. All labels/identification shall be positioned such as to be readable from the normal perspective without adjusting wiring/cables/labels. For example, labels/identification of wires/cables within cable trays shall be positioned to point towards the viewer (typically downward for overhead cable trays, or upward for cable trays within trenches).

D. All labels/identification (except for handwritten labels on concealed pullbox/junction box covers as noted below) shall be typewritten/printed/engraved in a neat, workmanlike, permanent, legible, consistent and meaningful manner. Labels shall not be handwritten unless specific approval is granted by engineer.

3.2 WIRE AND CABLE IDENTIFICATION

A. General:
   1. Where cabling is exposed (such as within cable trays), provide two wire ties per cable (one on either end of marker plate to provide a flush installation). Where cabling is concealed (such as within pullboxes/wireways), one wire tie per cable will be acceptable.

B. Intermediate Locations:
   1. Thermal transfer labels shall be securely fastened to all wiring and cabling in the following locations:
      a. Wireways
      b. Pullboxes/Junction boxes larger than 4-11/16”
      c. Pullboxes/Junction boxes through 4-11/16” where wires and cables are not easily identifiable via the color coding and box labeling
      d. Vaults & Manholes
      e. Approximately every 50 feet within cable trays (especially at locations where cables exit or diverge). Labels within cable trays shall be grouped (rather than being pre-labeled on cables and pulled into cable trays).
      f. Other similar intermediate locations.
   2. Labels shall be stamped or printed with the following data so that the feeder or cable can be readily identified and traced:
      a. From where the circuit originates (including panel designation and circuit number):
         1) Ex: “FROM: PP-A CIR. 3 (IN MAIN ELEC ROOM)”
      b. To where the circuit extends (using the common name of the equipment):
         1) Ex: “TO: RTU-6 (ON ROOF)”
      c. The purpose of the circuit:
         1) Ex: “POWER”
      d. The set number (If parallel power feeds are used).

1) Ex: “SET NO. 3 OF 4”

C. Circuit/Cable Termination Locations:
1. Where multiple termination points exist within a circuit origination point (panelboard, switchboard, MCC, starter, etc.) or other similar circuit endpoint (control panel, etc.), labels shall be securely fastened to all ungrounded and neutral conductors to clearly identify the terminal and/or circuit number associated with each conductor. For example, within lighting panels, each phase and neutral conductor shall be labeled near the terminals at a clearly visible location with the associated circuit number(s), so that if all conductors were unterminated, the labels would clearly indicate which conductor was associated with each circuit.

D. Refer to Specification Section 26 05 19 for all color-coding requirements of wires and cables.

3.3 PULLBOX & JUNCTION BOX IDENTIFICATION

A. Concealed pullboxes/junction boxes:
1. Front surface of all pullbox/junction box covers in concealed areas (such as above lay-in ceilings) or within mechanical/electrical rooms (and other similar areas where appearance of boxes is not an issue) shall be neatly marked with the ID of circuits/cables contained with permanent black marker on cover of box (Ex: “RP-1A Cir. 1, 2 & 3”). Additionally, front surface of box shall be painted red where box contains fire alarm system cabling.

B. Exposed pullboxes/junction boxes:
1. Interior surface of all pullbox/junction box covers in exposed areas shall be labeled “Power”, “Telecommunications”, “Fire Alarm” or with other similar general text neatly with permanent black marker to indicate function of box. Circuit/cable labeling within box (see above) shall identify specific cables contained. Additionally, interior surface of cover shall be painted red where box contains fire alarm system cabling.

C. Where pullboxes/junction boxes are named on contract documents (Ex:”PULLBOX #3”), an engraved nameplate shall be installed on the front surface of the box to identify the name.

3.4 ELECTRICAL DISTRIBUTION & UTILIZATION EQUIPMENT IDENTIFICATION

A. General:
1. All new and existing equipment modified by this project shall include arc-flash warning labels in accordance with NEC article 110.16.

B. All Panels, Motor Control Centers, Switchboards, Switchgear, Transformers, Etc.:
1. Engraved nameplates identifying name of equipment, nominal voltage and phase of the equipment and where the equipment is fed from shall be installed on front surface of all panels, motor control centers, switchboards, switchgear, transformers, etc.:
a. Ex: First Line: “NAME: RP-A”, Second Line: “120/208V-3Ø-4W”, Third Line: “FED FROM: PP-A CIR. 4 (IN MAIN ELEC ROOM)”
2. Refer to Panelboard Specification Sections for additional labeling requirements (circuit directory cards, permanent circuit labels, permanent circuit numbers, etc.) required inside panelboards.

C. Safety/Disconnect Switches and Utilization Equipment (HVAC Equipment, Pumps, Powered Valves, Control Panels, Starters, Etc.)::

1. Engraved nameplates identifying equipment being fed and where the equipment is fed from shall be installed on front surface of all disconnect switches (including both visible blade type switches and toggle-type switches) and on utilization equipment (where not clearly identified by immediately adjacent local disconnect switch):
   a. Ex: First Line: "RTU-6", Second Line: "FED FROM: PP-A CIR. 5"
2. Where safety/disconnect switches are installed on the load side of variable frequency drives, the safety/disconnect switch shall be furnished with an additional engraved nameplate to read: "WARNING: TURN OFF VFD PRIOR TO OPENING THIS SWITCH".
3. Safety/Disconnect switches feeding equipment that is fed from multiple sources (such as motors with integral overtemperature contacts that are monitored via a control system) and Utilization Equipment fed from multiple sources shall be furnished with an additional BLACK-ON-YELLOW engraved nameplate to read: "WARNING: ASSOCIATED EQUIPMENT FED FROM MULTIPLE SOURCES – DISCONNECT ALL SOURCES PRIOR TO OPENING COVER".

D. Emergency Systems:
1. A sign shall be placed at the service entrance equipment (and at any remote shunt trip operators, or similar, for service equipment) indicating the type and location of on-site emergency power sources (such as generators, central battery systems, etc.) per NEC requirements.
2. All boxes and enclosures (including transfer switches, generators, power panels, junction boxes, pullboxes, etc.) dedicated for emergency circuits shall be permanently marked with white-on-red engraved nameplates so they will be readily identified as a component of an emergency circuit or system.
3. Where an Essential Electrical System (EES) is installed, all enclosures, raceways and equipment that are components of the EES shall be readily identified as such. Raceway shall be identified at intervals not exceeding 25 ft.

E. Services:
1. All Service Equipment:
   a. Engraved nameplates identifying maximum available fault current, including date the fault current calculation was performed, in accordance with NEC article 110.24.
      1) Ex: First Line: "AVAILABLE FAULT CURRENT: 16,154 AMPS", Second Line: "DATE CALCULATED: JULY 8, 2013"
   b. All service entrance equipment shall be clearly labeled as being service entrance rated.
2. Where a building or structure is supplied by more than one service (or any combination of branch circuits, feeders and services), a permanent plaque or directory shall be installed at each service disconnect location denoting all other services, feeders & branch circuits supplying that building or structure and the area served by each, per NEC requirements.

F. Generators:
1. Generators shall be labeled with engraved nameplates identifying name of equipment.

3.5 EMERGENCY AND STANDBY POWER RECEPTACLE IDENTIFICATION

A. Receptacles fed from emergency or standby power sources (such as emergency generators) shall be provided with factory-marked engraved coverplates as described above.

3.6 OTHER IDENTIFICATION

A. Factory-engraved coverplates identifying functions of light switches and other similar devices shall be installed where so required by plans/specifications.

END OF SECTION 26 05 53

SECTION 26 05 73

POWER DISTRIBUTION SYSTEM ELECTRICAL STUDIES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. THE WORK UNDER THIS SECTION INCLUDES BUT IS NOT LIMITED TO THE FOLLOWING:
1. Power Distribution System Electrical Studies.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Short Circuit Studies, Protective Devices Evaluation Studies, Protective Device Coordination Studies and Arc Flash Hazard Studies shall be performed by the same entity, which shall be a Professional Engineer registered in the state where the equipment will be installed. The studies shall be per the requirements set forth in the latest edition of NFPA 70E-Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D.

B. The studies shall be submitted to the Architect prior to shipment of any electrical distribution equipment.

C. The studies shall include all portions of all electrical systems affected by the project (including any existing systems/equipment) from the utility service to any existing equipment at the facility (including all existing equipment fed from the same service point as any new equipment) and to all new equipment installed under this contract. All induction motors 50 HP or below and fed from the same bus may be grouped together. All induction motors greater than 50 HP shall be included individually with associated starters and feeder impedance. See individual study sections below for additional scope requirements.

D. The studies shall be performed using the latest revision of the SKM Systems Analysis Power*Tools for Windows (PTW) or EasyPower software program.

E. Normal system connections and those which result in maximum fault conditions shall be adequately covered in the study.

F. The contractor shall be responsible for collecting data on any existing or proposed electrical equipment, devices, conductors, etc. as required to prepare the study, and shall supply pertinent electrical system conductor, circuit breaker, generator, and other component and system information in a timely manner to allow the studies to be completed prior to shipment of equipment.

G. The Power Distribution System Electrical Studies shall be performed by Square 'D', G.E., Siemens or Cutler Hammer; or a third-party vendor if specifically approved by the engineer prior to preparation of the studies.

H. The proposed vendor shall have completed a minimum of five (5) equivalent Arc-Flash Hazard Studies in the past three (3) years.

2.2 SHORT CIRCUIT STUDY

A. The Short Circuit Study shall be performed with aid of a computer program. The study input data shall include the power company's short circuit contribution, resistance and reactive components of the branch impedances, X/R ratios, base quantities selected, and other source impedances.

B. Short circuit momentary duty values and interrupting duty shall be calculated on each individual basis with the assumption that there is a three-phase bolted short circuit at the respective switchgear bus, switchboard, low voltage motor control center, distribution panelboard, and other significant locations throughout the system.

C. The short circuit tabulation shall include symmetrical and asymmetrical fault currents, and X/R ratios. For each fault location, the total duty on the bus, as well as the individual contributions from each connected branch, including motor back EMF current contributions shall be listed with its respective X/R ratio.

2.3 PROTECTIVE DEVICE EVALUATION STUDY

A. The Protective Device Evaluation Study shall be performed to determine the adequacy of circuit breakers, switches, transfer switches, and fuses by tabulating and comparing the short circuit rating of these devices with the calculated fault currents. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied.

B. Any problem areas or inadequacies in the equipment due to short circuit currents shall be promptly brought to the Architect's attention.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. The Protective Device Coordination Study shall be performed to provide the necessary calculation and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage breaker trip characteristics and settings. The objective of the study is to obtain optimum protective and coordination performance from these devices.

B. The coordination study shall show the best coordination attainable for all breakers down through the largest breaker at each piece of distribution equipment. Coordination study shall demonstrate selective coordination where required by applicable codes or contract documents.

C. Phase and ground overcurrent protection shall be included as well as settings of all other adjustable protective devices. Where ground fault protection is used, coordination of the ground fault protection with the first downstream overcurrent phase protection device shall be demonstrated.

D. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic curves be maintained.

2.5 ARC-FLASH HAZARD STUDY

A. The Arc-Flash Hazard Study shall be performed with the aid of computer software intended for this purpose in order to calculate Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances.

B. The Arc-Flash Hazard Study shall be performed in conjunction with a short-circuit Study and a time-current coordination Study.

C. The Arc-Flash Hazard Study shall be performed for the following equipment:
   1. All Distribution Equipment – This includes but is not limited to the following:
      a. Switchgear
      b. Switchboards
      c. Motor Control Center
      d. All Lighting and Power Panelboards
      e. Fused Disconnect Switches rated greater than 100A
   2. Separately enclosed devices fed from protection device rated greater than100A - This includes but is not limited to the following:
      a. Control Panels
      b. VFD's
      c. RVSS

D. A generic Arc-Flash label shall be applied to other electrical equipment that has not been included in the study. This includes but is not limited to the following equipment:
   1. Non-fused Disconnect Switches
   2. Fused Disconnect Switches rated 100A or less
   3. Transformers
   4. Control Panels, VFD's, RVSS, etc. rated 100A or less

E. Where a main protective device is provided, the study shall be performed on the line side and load side of the main. The worst-case result shall be used for the study result and label.

F. The Study shall be performed under worst-case Arc-Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

G. Where incident energies are calculated to fall within the high marginal region of a given Hazard/Risk Category Level, the Hazard/Risk Category Level shall be increased one level.

H. The Arc-Flash Hazard Study shall be performed in compliance with the latest IEEE Standard 1584, the IEEE Guide for Performing Arc-Flash Calculations. Where IEEE 1584 does not have a method for performing the required arc-flash calculations (such as for single phase equipment), calculations shall be performed and system shall be modeled using modules/methods as recommended by the arc flash software supplier (for example, using SKM Unbalanced/Single Phase Studies module for modeling single phase systems).

I. Equipment labels to identify AFIE and appropriate Hazard/Risk Category in compliance with NFPA 70E and ANSI Z535.4 (latest version of these requirements) shall be provided to the Electrical Contractor. The Electrical Contractor shall affix the labels to the distribution equipment devices as directed by the equipment manufacturer. These labels shall, at a minimum, include the following:
   1. WARNING label.
   2. Hazard/Risk Category.
   3. Arc Flash Boundary Distance.
   4. Incident Energy (in cal/cm2) at Working Distance.
   5. Shock Hazard Voltage.

6. Limited Approach Boundary Distance.
7. Restricted Approach Boundary Distance.
8. Prohibited Approach Boundary Distance.
9. Equipment Name.
10. Name of Firm who prepared the Study.
11. Project Number of the Firm who prepared the Study.
12. Date that the Study was prepared.
13. Method for calculating analysis data.
14. Statement to read: "Any system modification, adjustment of protective device settings, or failure to properly maintain equipment will invalidate this label" (or equivalent).

PART 3 - EXECUTION

3.1 SUBMITTAL REQUIREMENTS

A. The results of the studies shall be summarized in a final report. The report shall include the following sections:
   1. General:
      a. Description, purpose, basis and scope of the studies
      b. Single line diagram of the portion of the power system which is included within the scope of the work. The single line diagram shall fit on one sheet of paper (size as required) unless approved otherwise by engineer. The following information shall be shown on the single line diagram:
         1) Device Name
         2) Branch Fault Currents with directional indicators
         3) General Location (for busses only)
         4) Other basic component information such as cable type, cable length, breaker rating, buss short circuit rating, transformer voltages, transformer size, fuse size, etc..
   2. Short Circuit Study:
      a. Tabulation of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
   3. Protective Device Evaluation/Coordination Study:
      a. Protective devices time versus current coordination curves**,** tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
      b. Fault current calculations including definitions of terms and a guide for interpretation of computer printout.
      c. Documentation from utility company on their letterhead showing their anticipated values of available short circuit currents X/R ratios and protective devices with which the power distribution system will coordinate.
      d. Time-current characteristics of the respective protective devices shall be plotted on log-log paper. Plots shall be printed in color with a dedicated color and pattern for each curve for clear identification.
      e. Plots shall include complete titles, respective single line diagrams and legends, and associated power company's relay or fuse characteristics, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breakers trip curves and fuses.

f. The coordination plots shall indicate the type of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits and significant symmetrical and asymmetrical fault currents.
g. The coordination plots for phase and ground protective devices shall be provided on a system basis.
h. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.

4. Arc-Flash Hazard Study:
   a. Tabulation of device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and AFIE levels.
   b. Recommendations for reducing AFIE levels and enhancing worker safety.

B. Furnish all labor, materials, calculations, electrical equipment, technical data and incidentals required to provide a complete short circuit study, coordination study and arc flash hazard study of protective devices, busses, etc. from the utility service to any existing equipment at the facility and all new equipment installed under this contract.

C. The study shall comply with the following applicable provisions and recommendations of the latest revisions of the following: ANSI C37.5, IEEE Standard No. 399, and IEEE Standard No. 141.

D. Submit calculations and results of the short circuit, protective device evaluation and coordination and arc flash hazard studies prior to submitting shop drawings for new equipment. Contractor shall verify that all proposed equipment is properly rated per the short circuit and protective device evaluation portions of the study prior to releasing equipment for manufacturing.

E. Submit a copy of a sample typical arc flash label layout (meeting requirements outlined above) that will be used for the project.

F. Submit final electronic copies of all SKM program files/models/input data/etc. used to perform the study to the owner with final close-out documents. These files shall be complete as required to allow future users to recreate the study.

3.2 INSTALLATION

A. Contractor shall adjust all breaker settings as recommended by the coordination study prior to energizing equipment.

B. Contractor shall affix arc flash hazard notification labels (as determined by the results of this study) to each piece of distribution equipment prior to energization of equipment. A generic arc-flash warning label shall be affixed to any electrical equipment not included in the analysis as outlined above.

C. Where short circuit rating of equipment is dependent on setting of upstream overcurrent device, provide and install label for equipment indicating the required settings of the associated device.

END OF SECTION 26 05 73

SECTION 26 09 43

LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.1 INTRODUCTION

A. The work covered in this section is subject to the requirements in the General Conditions of the Specifications. Contractor shall coordinate the work in this section with the trades covered in other sections of the specification to provide a complete and operable system.

1.2 SYSTEM DESCRIPTION

A. Extent of lighting control system work is indicated by drawings and by the requirements of this section. Contractor shall furnish and install a complete, integrated, stand alone automatic lighting control system including programmable Lighting Control Panels with internal astronomic timeclock(s), Networking between panels, Dataline low voltage control switch inputs for zone control, Photocell input for outdoor lighting control, Occupancy Sensors, and Daylighting Controls from a single supplier. Contractor is responsible for confirming that the panels and sensors interoperate as a single system.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Comply with NEC, NEMA, and FCC Emission requirements for Class A applications.

C. UL Approvals: Relay panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Configured to order or custom relay panels shall be UL Listed under UL 508, Industrial Control Panels.

1.4 SUBMITTALS

A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
   1. Shop Drawings: Building floorplans showing all proposed devices and composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
   2. Product Data: Catalog sheets, specifications and installation instructions.

1.5 APPROVED MANUFACTURERS

A. Acuity Lighting

B. Equal by Wattstopper or Hubbell

C. Any other system wishing to be considered must submit descriptive information 10 days prior to bid. Prior approval does not guarantee final approval by the electrical engineer. The contractor shall be completely

responsible for providing a system meeting this specification in its entirety. All deviations from this specification must be listed and individually signed off by the consultant.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROL PANELS

A. Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:

1. Enclosure/Tub shall be NEMA 1, NEMA 3R, or NEMA 4 as indicated on the plans, sized to accept an interior with 1-8 relays, 1-24 relays and six (6) four pole contactors, or 1-48 relays with six (6) four pole contactors, per enclosure. Multiple enclosures shall be provided where required for the specified quantities of relays/contactors.
2. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
3. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (class 1) wiring from low voltage (class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:
    a. Provision for one or two optional control and automation cards.
    b. Removable, plug-in terminal blocks with screw less connections for all low voltage terminations.
    c. Individual terminal block, override push button, and LED status light for each relay
    d. Switch inputs associated with each relay and group channel shall support two or three wire, momentary or maintained contact switches or 24VDC input from occupancy sensors.
    e. Automatic support for occupancy sensor sequence of operation. Low voltage inputs automatically reconfigure when connected to a Watt Stopper occupancy sensor head. Occupancy sensor shall switch lighting on and off during unoccupied periods but shall not turn lighting off during scheduled occupancy periods.
    f. Isolated contacts within each relay shall provide true relay state to the electronics. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems.
    g. Automatic sequenced operation of relays reduces impact on the electrical distribution system when large loads are controlled simultaneously.
    h. Group, channel, and pattern control of relays shall be provided through a simple button-press interface within the panel. Any group of relays can be associated with a channel for direct on/off control or pattern (scene) control via a simple programming sequence using the relay and channel override push buttons and LED displays.
    i. Relay group status for each channel shall be provided through bi-color operation of the LED indicators. Solid red indicates that all relays in the group are on, solid green indicates that the group is in a mixed state, and blinking green indicates that the relays have blink warned and are currently timing out.

j. Each relay and channel terminal block shall provide a 24V pilot light signal. It shall be possible to configure the system for support for any Class 2 pilot light voltage with the use of an auxiliary power supply.

k. Single pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:
   1) Electrical:
      a) 30 amp ballast at 277V
      b) 20 amp ballast at 347V
      c) 20 amp tungsten at 120V
      d) 30 amp resistive at 347V
      e) 1.5 HP motor at 120V
      f) Short circuit current capacity equal to (or greater than) that of the associated circuits (see associated panelboard schedules on drawings)
   2) Mechanical:
      a) Individually replaceable, ½" KO mounting with removable Class 2 wire harness
      b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel
      c) Dual line and load terminals each support two #14 – #12 solid or stranded conductors
      d) Tested to 300,000 mechanical on/off cycles
   3) Isolated low voltage contacts provide for true relay status feedback and pilot light indication.

l. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.

2.2 LONWORKS® BASED DIGITAL COMMUNICATIONS

A. The lighting control panel shall support digital communications to facilitate the extension of control to include multiple panels and other intelligent field devices. Digital communications shall be LonWorks® based and use the LonTalk® protocol in an open topology architecture.
   1. Dataline communications wire shall be 18 AWG, 4 unshielded copper conductors (two independent twisted pairs) meeting Class 2P NEC code requirements. The dataline shall be topology free and can be run in a serial, "T"or star configuration.
   2. The Dataline wire will be supplied by the equipment manufacturer and will include the manufacturers name, catalog number printed on the wire jacket. The contractor, at their own expense will, replace an improper dataline wire.
   3. Panels shall be digitally addressed and support bi-directional communication between each other and other intelligent field devices specified elsewhere.
   4. Intelligent field devices supported shall include digital dataline switches, network clock/programmer, telephone interface module, BMS interface module, photocell control module, programmable thermostat, and universal switch module.

2.3 BROWSER BASED PROGRAMMING AND CONTROL

A. The lighting control system shall include a web browser based user interface that shall allow

programming and override of the system from any PC browser with network connectivity to the lighting controls. The Automation Appliance shall include as a minimum the following features:

1. The interface shall be a TCP/IP based server device that is connected to the lighting control system global dataline and shall not require that software be installed on the client PC(s) for operation.
2. Provide support for connection of one or more personal computers directly via Ethernet or enterprise connectivity via a local area network, wide area network or internet connection.
3. Provide the option for a plug-in 56K baud modem to enable dial in connection via standard telephone line. All functionality of the browser interface shall be available through the dial-up connection.
4. Log in to the lighting control system through the browser interfaced shall provide multi-level security. Users shall be assigned log in access levels to restrict program modification to authorized users.
5. User programming shall include eight independent schedules for each lighting control panel, as well as, eight global schedules that affect channels in all panels on the network. Schedules shall overlap such that a panel specific schedule for any channel will override a global schedule for that channel.
6. Schedules shall be capable of seven day repeating and calendar date event based formats.
7. User programming shall be scenario based and shall include the following options:
   a. Scheduled ON / OFF
   b. Manual ON / Scheduled OFF
   c. Manual ON / Auto Sweep OFF (for AS-100 Switches)
   d. Astro ON / OFF (or Photo ON / OFF)
   e. Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)
8. It shall be possible to view the status of and override any relay or channel group via the browser interface screens.
9. Provide support and user interface screens for integration of the photocontrol module, dataline switches, touch-tone telephone module, and universal switch module.
10. Provision for integration with the building automation system shall be via the industry standard BACnet protocol. Any of the eight global schedule channels shall individually be set to follow the BAS schedules rather than the internal Automation Appliance schedules. Relays in all panels shall be exposed to the BAS as binary output objects. It shall be possible for the BAS to read the status of each relay and to override each relay via BACnet.
11. The interface shall monitor all networked components and automatically generate alarms if any component fails to properly respond to control. Alarms shall be annunciated via the browser screens and via email to selected recipients where a proper SMTP server connection has been set up.
12. The user programming in the lighting control panels and dataline switches shall be available for viewing or download to the client PC as a standard PDF file.
13. A backup function shall permit the complete system program to be saved to the hard drive of any client PC connected to the lighting control system through the browser interface. A restore function shall allow a saved program to be reloaded to the interface.

2.4 EIGHT CHANNEL DIGITAL PHOTOCONTROL MODULE

A. Provide a weatherproof Class 2 photocell for measuring exterior light levels. The photocell shall be mounted facing north as indicated on the plans. The photocell shall be connected to a photocontrol module mounted on the DIN rail inside the low voltage section of a lighting control panel and connected

to the dataline communications wire.

1. The photocontrol Module shall integrate seamlessly with either the Network Clock, Automation Appliance, or the BMS Interface Module. The control module shall measure the actual exterior light and display this level in foot candles (fc) on the unit LCD display.
2. The controller shall have eight individual set point adjustments that are available to the lighting control network over the dataline communications wire.
3. Features
    a. Real time, 2 line LCD display of actual exterior light level up to 200 fc.
    b. Channel set points and parameters programmed via the Network Clock or BMS Interface Module.
    c. Choice of OPERATE or TEST modes, with simulated light level for testing.
    d. Automatic dead band and 5 minute time delay to avoid cycling.

2.5 DIGITAL DATALINE SWITCHES

A. Intelligent digital switching shall be provided operating on the dual twisted pair communication wire. Switches shall be available in single, dual, quad, or octal (1-button, 2-button, 4-button, or 8-button) designs. The single, dual, and quad devices shall mount in a standard single-gang box, the octal version in a two-gang box.

1. Each button shall be individually programmable. Programming of buttons shall not require the use of a computer or other programming device. It shall be possible to assign relays or channels to buttons using a simple button press interface. Each button can control any one of the following options:
    a. Any individual relay in any single panel.
    b. Any group of relays in any single panel.
    c. Any group of relays in the system (via network clock, Automation Appliance, or WinControl software package).
2. For applications that require pattern switching, buttons shall function as a scene control using an ON/OFF/Not Controlled pattern of relays instead of the normal All ON/OFF.
3. Switches shall be constructed of non-breakable grey Lexan on all exposed parts and shall include a stainless steel wall plate, unless noted otherwise on plans.
4. Individual buttons shall have a removable clear cover to allow standard 9 mm (3/8 inch) labeling tape to be used to identify the controlled loads.
5. Each switch shall use a bi-color LED pilot light for the individual buttons to indicate status of the controlled relay or group of relays. LED indications are Red for All ON, Green for Mixed State (some relays in the group ON and others OFF), and No LED for All OFF.
6. Switch LED pilot lights shall flash green to indicate impending off sweep during the five-minute grace period following blink warning of the lights. Once the button is pressed, the LED will change to Red to acknowledge the occupant's override command to keep lights ON.
7. Multiple dataline switches programmed to control the same relay or relay group shall indicate the same status automatically.
8. Each switch shall also include a locator light illuminating the switch for easy location in the dark.
9. The dual, quad, and octal switches shall all include a single master button that will override all relays controlled by the individual buttons OFF, or Restore them to their original state. Each switch's master button configuration can be altered to perform a Master ON/OFF, OFF Only, or Disabled function if desired.
10. Switches can be configured to follow a "Cleaning" scenario. This specific scenario shall prevent the cleaners from overriding OFF any relays previously turned ON by an occupant.

11. Each switch is available in a Key lock override version. Once a key is inserted, the individual buttons will function for five minutes.

2.6 AUTOMATIC LIGHTING CONTROLS

A. System shall provide automatic lighting shutoff for all interior lighting circuits controlled by the system (excluding night lights and other similar circuits) per latest ASHRAE 90.1 & IECC standards, unless specifically shown otherwise on plans.

B. System shall provide blink-warnings for interior lighting circuits (excluding circuits with HID light fixtures) controlled by the control panel 5 minutes prior to automatic shutoff.

C. System shall include provisions for holiday scheduling, to allow automatic “ON” programming to be skipped on holidays and other scheduled off days per applicable energy code requirements.

D. Low voltage remote override switches shall be provided as shown on drawings.

E. Exact preset times for lighting control zone controls (where applicable) and lighting control system operation shall be per owner’s direction. Contractor shall submit a proposed lighting control schedule indicating type of “ON” control (occupancy, time-of-day, manual, etc.), type of “OFF” control (occupancy, time-of-day, manual, etc.) and proposed preset times for all zones to owner for review prior to implementation. The following general control schemes shall generally be used where the owner has no preferences unless shown otherwise on plans:
   1. Exterior Security Lighting (at doorways, etc.):
      a. On: Photocell or Astronomic – dusk.
      b. Off: Photocell or Astronomic – dawn.
   2. Other Exterior Lighting:
      a. On: Photocell or Astronomic – dusk.
      b. Off: Preset Time (as directed by the facility operator).
   3. Interior Lighting with Occupancy Sensor Controls:
      a. Corridors, restrooms, lobbies and other similar public spaces
         1) On: Occupancy Sensor.
         2) Off: Occupancy Sensor.
      b. Storage rooms, janitor's closets, telecommunications rooms, and other similar unoccupied spaces:
         1) On: Occupancy Sensor.
         2) Off: Occupancy Sensor.
      c. Offices, classrooms, breakrooms, conference rooms, work areas, kitchens, gymnasiums, and other similar occupied spaces:
         1) On:
            a) Manual Local Switch (if digital controls are provided) or
            b) Occupancy Sensor (if hardwired controls are provided).
         2) Off: Occupancy Sensor (A "grace period" shall be provided, in which the occupancy sensor can turn lights back "on" for a short period of time (approximately 15 seconds) after lights are turned off automatically).
   4. Interior Lighting with Time-of-Day Controls:
      a. Corridors, restrooms, lobbies and other similar public spaces
         1) On: Preset Time (as directed by the facility operator).

2) Off: Preset Time (as directed by the facility operator).

b. Storage rooms, janitor's closets, telecommunications rooms, and other similar unoccupied spaces:
   1) On: Manual Local Switch
   2) Off: Preset Time (as directed by the facility operator).

c. Offices, classrooms, breakrooms, conference rooms, work areas, kitchens, gymnasiums, and other similar occupied spaces:
   1) On: Manual Local Switch
   2) Off: Preset Time (as directed by the facility operator).

2.7 WIRING

A. See Specification Section 27 05 00 for additional requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Specification Section 27 05 00 for additional cable installation requirements.

B. Master/centralized lighting control switches (particularly switches located in areas where not all associated lighting fixtures are visible from the switch) and individual buttons of other lighting control stations with more than two (2) buttons shall be labeled (on switch coverplate or directly on buttons) with factory-engraved labeling. Exact wording of labeling shall be per owner's direction unless shown otherwise on plans.

3.2 SUPPORT SERVICES

A. Pre-installation Coordination
   1. Exact occupancy sensor and daylight sensor types and locations shall be determined by the lighting control system supplier for a fully-functional system with adequate coverage throughout areas controlled by occupancy sensors. Exact locations shall be coordinated with actual HVAC register locations, furniture/casework/etc. locations, sensor coverage patterns, etc. for proper coverage in all areas. In no case may fewer devices or lower-quality devices be used in each area than indicated on contract documents.

B. System Start Up and Commissioning
   1. The electrical contractor shall provide the manufacturer, the facility owner and the electrical engineer with ten working days written notice of the system startup and adjustment date.
   2. Manufacturer shall provide a factory authorized technician to confirm proper installation and operation of all lighting control system components. The startup requirement is intended to verify:
      a. That all occupancy and daylighting sensors are located, installed, and adjusted as intended by the factory and the contract documents.
      b. The occupancy sensors and daylighting sensors are operating within the manufacturers specifications.
      c. The sensors and relay panels interact as a complete and operational system to meet the design intent.

3. Manufacturer to provide a written statement verifying that the system meets the above requirements.

C. Re-commissioning – After 30 days from occupancy re-calibrate all preset times, sensor time delays and sensitivities and relocate occupancy sensors if so required to meet the Owner's Project Requirements. Provide a detailed report to the Design Team and Owner of re-commissioning activity.

D. System Training
1. Manufacturer shall provide factory authorized technician to train owner personnel in the operation, programming and maintenance of the lighting control system including all occupancy sensors and daylighting controls.

E. System Programming
1. Manufacturer shall provide system programming including:
   a. Wiring documentation.
   b. Switch operation.
   c. Telephone overrides.
   d. Operating schedules.

3.3 WARRANTY

A. The contractor shall warrant the completed lighting control system to be free from inherent mechanical and electrical defects for a period of one (1) year from the date of the completed and certified test or from the date of first beneficial use.

END OF SECTION 26 09 43

SECTION 26 09 44

DISTRIBUTED DIGITAL LIGHTING MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Digital Occupancy and Daylighting Sensor Control
2. Emergency Lighting Control (if applicable)

B. Related Section
1. Section 26 09 43 – Lighting Control System
2. Section 26 27 26 - Wiring Devices
3. Section 27 05 00 – Auxiliary System Cables, 0-50V
4. Section 26 50 00 – Lighting Materials and Methods
5. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section
6. Electrical Sections, including wiring devices, apply to the work of this Section.

C. Control Intent – Control Intent includes, but is not limited to:
1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
2. Initial sensor and switching zones
3. Initial time switch settings
4. Task lighting and receptacle controls
5. Emergency Lighting control (if applicable)

1.2 REFERENCES

A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)

B. Underwriter Laboratories of Canada (ULC)

C. International Electrotechnical Commission

D. International Organization for Standardization (ISO)

E. National Electrical Manufacturers Association (NEMA)

F. WD1 (R2005) - General Color Requirements for Wiring Devices.

G. Underwriters Laboratories, Inc. (UL):
1. 916 – Energy Management Equipment.
2. 924 – Emergency Lighting
3. 2043 – Plenum Rating

1.3 SYSTEM DESCRIPTION & OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:
   1. Digital Room Controllers – Self configuring, digitally addressable one, two or three relays controllers with 0-10v control for ballasts (if applicable) and single relay application specific plug load controllers.
   2. Digital Occupancy Sensors connected to Digital Room Controllers – Self configuring, digitally addressable and calibrated occupancy sensors with LCD screens and two way active Infra-Red (IR) communications.
   3. Digital Switches connected to Digital Room Controllers – Self configuring, digitally addressable push button switches, dimmers, and scene switches with two way active Infra-Red (IR) communications.
   4. Analog and digital closed loop daylighting sensors connected to Digital Room Controllers - self-calibrating daylighting sensors that provide closed loop control to Room Controllers. Sensors and Room Controllers can provide single or multi-zone, on/off or dimming control for daylight harvesting.
   5. Hand held remotes for room configuration – provides two way infrared communications to digital devices and allows complete configuration and reconfiguration of the device / room from 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow send / receive / store of room variables.
   6. Hand held remotes for personal control – One, two, or four (scene) button remotes provide Infrared communications to a room. Remote controls will support ON/OFF, dimming, scene control and may be configured in the field to provide specific occupant requirements without special tools.
   7. Digital Lighting Management (DLM) local network – Free topology, plug in wiring system (Cat 5e) for power and data to room devices.
   8. Network Bridge - provides BACnet MS/TP compliant digital networked communication between rooms, panels and the Segment Manager or BAS.
   9. Segment Manager - provides web browser based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.
   10. Emergency Lighting Control Unit (ELCU)- allows any standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building

1.4 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:
   1. Space Control Requirements – Provide occupancy/vacancy sensors with manual-on functionality in all spaces except toilet rooms, storerooms, library stacks, or other applications where hands-free operation is desirable and automatic-on occupancy sensors are more appropriate. Provide manual ON occupancy/vacancy sensors for any enclosed office, conference room, meeting room, open plan system and training room. For spaces with multiple occupants or where line-of-sight may be obscured, provide ceiling- or corner-mounted sensors with manual-on switches.
   2. Bi-Level Lighting – Provide multi –level switched dimming controls where indicated on plans.
   3. Task Lighting / Plug Loads – Provide automatic shut off of non essential plug loads and task lighting where indicated on plans. Provide automatic ON of plug loads whenever spaces are occupied. For spaces with multiple occupants a single shut off consistent with the overhead lighting may be used for the area.

4. Daylighted Areas. Provide daylighting controls where indicated on plans. Daytime set points for total illumination (combined daylight and electric light) level that initiate dimming shall be programmed to be not less than 125% of the nighttime maintained designed illumination levels.
5. Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
6. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylight system may be designed to turn off ambient lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.

1.5 SUBMITTALS

A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
   1. Shop Drawings: Building floorplans showing all proposed devices and composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
   2. Product Data: Catalog sheets, specifications and installation instructions.

1.6 QUALITY ASSURANCE

A. Manufacturer: Minimum [10] years experience in manufacture of lighting controls.

1.7 PROJECT CONDITIONS

A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
   1. Ambient temperature: 0° to 40° C (32° to 104° F).
   2. Relative humidity: Maximum 90 percent, non-condensing.

1.8 WARRANTY

A. Provide a five year complete manufacturer's warranty on all products to be free of manufacturers' defects.

1.9 MAINTENANCE

A. Spare Parts:
   1. Provide two (2) of each product to be used for maintenance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer:
   1. nLight Distributed Lighting Control System
   2. Wattstopper
   3. Hubbell

B. Basis of design product: nLight by Acuity

1. Substitutions:
   a. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
   b. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power wiring) with deviations for the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.2 SINGLE / DUAL RELAY WALL SWITCH VACANCY SENSORS

A. Type PW: Manual ON, Automatic OFF Wall switch type passive infrared occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

B. Type UW: Manual ON, Automatic OFF Wall switch type ultrasonic occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

C. Type DW: Manual ON, Automatic OFF Wall switch type dual technology, passive Infrared and ultrasonic occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

2.3 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM

A. Wall or ceiling mounted (to suit installation) passive infrared, ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company's system which accommodates the square footage coverage requirements for each area controlled, utilizing Room Controller modules and accessories which suits the lighting and electrical system parameters.

B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation . Features include the following:
   1. Digital calibration and LCD entry for the following variables:
      a. Sensitivity 0-100% in 10% increments
      b. Time Delay – Fixed (1-30 minutes in 1 minute increments), and automatic
      c. Test mode – Five second time delay
      d. PIR, Ultrasonic or Dual Technology activation and/or re-activation.
      e. Walk-through mode
      f. Load parameters including auto/manual ON, blink warning, and daylight enable/disable.
   2. RJ-45 digital connections for local network.
   3. Two-way infrared communications port to allow remote programming through hand held commissioning tool.
   4. Self contained push buttons for programming and control of room devices.

5. Device Status LED's including:
    a. PIR Detection
    b. Ultrasonic detection
    c. Configuration mode
    d. Load binding
6. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.

C. Units will provide for digital calibration and commissioning and will not have any dip switches or potentiometers for field settings

D. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology local network. No additional configuration will be required

2.4 DIGITAL WALL SWITCHES

A. Low voltage (RJ-45) momentary push button switches in 1,2,3,4 and 8 button configuration, decorator opening. Wall switches will include the following features:
1. Two way infrared communications port for use with personal and configuration remote controls.
2. Engraveable buttons
3. Dimming switches shall include seven LED's to indicate load levels.
4. Scene switches shall include pilot indication of scene selection.
5. Device Status LED's including:
    a. One pilot LED for each button.
    b. Power Indication
    c. One locator LED per switch
    d. Network status LED to indicate data transmission
    e. Power LED to indicate the device has power
    f. Configuration mode

B. Switches shall have two RJ-45 ports to allow connection to any other digital room device.

C. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology local network. No additional configuration will be required to achieve multi-way switching

2.5 ROOM CONTROLLERS

A. Room Controllers automatically bind the room loads to the connected devices in the space without any tools or configuration requirements. Room Controllers shall be provided to match the room lighting load and control requirements and sequences. The controllers will be simple to install and will not have screw type connections, dip switches, potentiometers or require special mounting or configuration. The control units will include the following features:
1. Automatic room configuration to the most energy efficient sequence of operation based upon the devices in the room.
2. One or two relay configuration
3. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an Off-the-Shelf unit without requiring any configuration or setup.
4. Device Status LED's to indicate:
    a. Data transmission

b. Device has power
c. Status for each load
d. Configuration status

5. Quick installation features including:
   a. Standard junction box mounting (inside or outside)
   b. Quick low voltage connections using standard RJ-45 patch cable
6. Plenum rated
7. Manual override and LED indication for each load
8. Universal voltage (120/230/277 VAC, 50-60 Hz)
9. Zero cross circuitry for each load.
10. Efficient 150 ma switching power supply
11. Local network ports

B. 0-10 Volt enhanced Room Controllers shall include all the features of the Room Controller plus the following enhancements:
   1. One, two or three relay configuration
   2. Efficient 250 ma switching power supply
   3. Local network ports.
   4. One zero to 10 volt analog output per relay for control of dimmable ballasts.
   5. Optional BACnet MS/TP communications port.
   6. Current monitoring

C. Plug Load Room Controllers provide dedicated control of plug loads within the space. The controllers plug into the local network using the RJ-45 free topology network. The room controllers include the following features
   1. One relay configuration only
   2. Automatic ON/OFF configuration
   3. Default 30 minute (adjustable) time delay from lighting shut off to allow for electronic component use after an area is vacant

2.6 DIGITAL PHOTOSENSORS

A. Provide automatic daylight harvesting capabilities to the Room Controllers. The photo sensor / room controller configuration automatically configures the daylighting set points for ON/OFF or Dimming control. Using the automatic configuration replacing a photo sensor or room controller can be done without any special tools, programming or configuration. Photosensors include the following features:
   1. The digital photosensor shall utilize an internal photodiode that measures light in a 100 degree angle cutting the unwanted light from bright sources outside of this cone
   2. The digital photosensor shall be capable of turning lighting on and off or Raise / Lower depending on the type of Room Controller (on/off or dimming). Sensor range shall be from 1 - 1400fc.
   3. For ON/OFF daylight harvesting the controller provides a "hold on while occupied" feature that prohibits high levels from turning OFF the controlled lights as long as the space remains occupied.
   4. The sensor has a threaded nipple that mounts on a ceiling tile and for more challenging applications such as a side wall or hard rock ceiling the nipple pops off and the unit can be screwed down

2.7 ROOM NETWORK

A. The local network is a free topology lighting control network and protocol designed to control a small area of a building. Digital room devices connect to the network using RJ-45 patch cords which provide both data and power to room devices. Features of the local network include
   1. Automatic configuration and binding of sensors, switches and lighting loads to the most energy efficient sequence of operation based upon the device attached.
   2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
   3. Push and Learn configuration that can change the automatic binding process and load parameters by using only the digital devices in the room.
   4. Two way infrared communications that allow load parameters, sensor configuration and binding operations to be configured through a hand held configuration tool up to 30 feet from any device

2.8 NETWORK BRIDGE

A. Each local network shall include a network bridge component to provide a connection between the room devices and the segment network. The network bridge shall use industry standard BACnet MS/TP network communication and allow direct connection to the Segment Manager or BAS where required.

B. The network bridge may be incorporated directly into the room controller hardware or be provided as a separate module connected on the local network through an available RJ local network port

C. Provide Plug and Go operation to automatically discover all room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.

D. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet compliant BAS to include lighting control and power monitoring features as provided by the room devices on each local network. Standard BACnet objects shall be provided .

2.9 SEGMENT MANAGER

A. The Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser. Each segment manager shall have support for one, two or three segment networks as required and allow for control of a maximum of 127 local networks (rooms) and or lighting control panels per segment network.

B. Operational features of the Segment Manager shall include the following:
   1. Connection to PC or LAN via standard Ethernet TCP/IP
   2. Easy to learn and use Adobe Flex based GUI compatible with Internet Explorer 8 or equal browser
   3. Log in security capable of restricting some users to view-only or other limited operations
   4. Automatic discovery of all devices on the segment network(s). Commissioning beyond activation of the discovery function shall not be required.
   5. After discovery all rooms and panels shall be presented in a standard navigation tree format
   6. View and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation.
   7. Set up schedules for rooms and panels. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation.

8. Group rooms and loads for common control by schedules, switches or network commands. Monitor connected load current for rooms or zones equipped with room controllers incorporating the current monitoring feature
9. Provide seamless integration with the BAS via BACnet IP

2.10 EMERGENCY LIGHTING

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include
1. 120 - 277 volts, 50/60 Hz., 20 amp ballast rating
2. Push to test button
3. Auxiliary contract for test / Fire Alarm system

2.11 WIRING

A. Refer to Specification Section 27 05 00 for additional requirements.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION COORDINATION

A. Exact occupancy sensor and daylight sensor types and locations shall be determined by the lighting control system supplier for a fully-functional system with adequate coverage throughout areas controlled by occupancy sensors. Exact locations shall be coordinated with actual HVAC register locations, furniture/casework/etc. locations, sensor coverage patterns, etc. for proper coverage in all areas. In no case may fewer devices or lower-quality devices be used in each area than indicated on contract documents.

3.2 INSTALLATION

A. When using wire other than RJ-45 connections provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements

B. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.

C. Provide all connections between system components and network connections to building LAN (via Ethernet cabling) as directed by system supplier for a fully functional networked system.

D. Calibrate all sensor time delays and sensitivity to guarantee proper coverage of occupants and energy savings.

E. Provide written or computer generated documentation on the commissioning of the system including room by room description including:
1. Sensor parameters, time delays, sensitivities, daylighting set points.
2. Sequence of operation, manual ON, Auto OFF. Etc.
3. Load Parameters - blink warning, etc.

F. Refer to Specification Section 27 05 00 for additional installation requirements.

3.3 SUPPORT SERVICES

A. System Start Up and Commissioning
   1. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.
   2. Manufacturer shall provide a factory authorized technician to confirm proper installation and operation of all lighting control system components. The startup requirement is intended to verify:
      a. That all occupancy and daylighting sensors are located, installed, and adjusted as intended by the factory and the contract documents.
      b. The occupancy sensors and daylighting sensors are operating within the manufacturers specifications.
      c. The sensors and relay panels interact as a complete and operational system to meet the design intent.
   3. Manufacturer to provide a written statement verifying that the system meets the above requirements.

B. Re-commissioning – After 30 days from occupancy re-calibrate all preset times, sensor time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Design Team and Owner of re-commissioning activity.

C. System Training
   1. Manufacturer shall provide factory authorized technician to train owner personnel in the operation, programming and maintenance of the lighting control system including all occupancy sensors and daylighting controls.

D. System Programming
   1. Manufacturer shall provide system programming including:
      a. Wiring documentation.
      b. Switch operation.
      c. Telephone overrides.
      d. Operating schedules.

END OF SECTION 26 09 44

SECTION 26 24 16

POWER PANELBOARDS - CIRCUIT BREAKER TYPE

PART 1 - GENERAL

1.1 GENERAL

A. The work under this section includes but is not limited to the following:
   1. Power Panelboards
   2. Power Circuit Breakers

PART 2 - PRODUCTS

2.1 PANELBOARDS - GENERAL

A. Panelboards shall be dead front type, having lugs only or circuit breaker in mains as shown in panelboard schedule with circuit breaker branches.

B. Panelboard bus structure and main lugs or main breaker shall have current ratings as shown on plans. Such rating shall be established by heat rise test with Maximum hot spot temperature on any connector or bus bar not to exceed 50 degrees C rise above ambient at full rated load. Heat rise test shall be conducted in accordance with UL Standard UL67. Bus structure shall be tin-plated copper. All neutral busses shall be full size. All panelboards shall contain ground buss.

C. Entire panelboard assembly, including all bussing, shall have SCCR ratings meeting or exceeding the minimum AIC ratings listed on the plans for the panel. All ratings shall be full ratings. Series ratings will not be allowed unless shown otherwise on drawings.

D. Panelboards shall be listed by Underwriters Laboratories and shall bear the UL label. Panelboards shall be suitable for use as service equipment when required.

E. Main and sub-feed lugs shall be provided with CU compression lugs suitable for the quantities and sizes of conductors required.

F. Top/bottom feed arrangement and lug sizes/quantities shall be coordinated by the contractor.

G. Service entrance panelboards shall be provided with barrier such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

2.2 CIRCUIT BREAKERS

A. Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated (or can be adjusted to is 1200A or higher, breakers shall be electronic trip and shall be provided with arc energy-reducing maintenance switching (with local status indicator) to reduce arc flash energy per NEC 240.87 requirements.

B. Circuit breakers shall be quick-make and quick-break, whether actuated automatically or manually. Circuit breakers shall have inverse time tripping characteristics with automatic release which shall trip free of the handle. Circuit breaker handles shall be three distinct positions—"OFF", "ON", and "TRIPPED". When a circuit breaker opens on overload or short circuit, the operating handle shall automatically assume the "TRIPPED" position.

C. Multipole breakers shall be internal common trip with single operating handle. External handle ties are not acceptable, unless specifically noted otherwise (such as for multi-wire branch circuits described below).

D. Circuit breakers feeding multiwire branch circuits (as defined by NEC) consisting of separate single phase loads sharing a common neutral shall be provided with handle ties to simultaneously disconnect all ungrounded conductors per NEC Article 210.4(B). The necessary locations of these handle ties shall be coordinated by the contractor. Where necessary, the contractor may rearrange circuit breakers (as minimally as possible) as required to meet this requirement.

E. Circuit breakers shall be of the bolt-on type.

F. Circuit breakers shall be "FA" frame and larger.

G. All breakers shall meet the minimum RMS symmetrical interrupting capacity ratings shown on plans for the associated panel. All interrupting ratings shall be full ratings. Series ratings will not be allowed unless shown otherwise on drawings.

H. The front face of all circuit breakers shall be flush with each other. Breaker numbers shall be permanently attached to trim.

I. All branch circuit breakers shall be listed to UL489 or shall be specially-tested to be HACR listed.

2.3 CABINETS, TRIM AND WIREWAY SPACE

A. Clear space from bottom of lugs to bottom of wireway shall be not less than 6 inches for 400 amps and below, 10 inches for 600 amps, 12 inches for 800 amps and above.

B. Panelboard interiors shall be fastened to cabinets by adjustable aligning supports.

C. Panelboard assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL Standard 50 for cabinets.

D. Fronts of cabinets shall be made from a single sheet of full finished steel having the door cut out. Doors shall have flush hinges, and lock utilizing all metal construction (with all locks keyed alike). Front shall be attached to cabinets with hinged trim with piano-hinge down full length of one side to allow access to wiring without complete removal of outer trim. Front shall be provided with a metal directory and holder with clear plastic covering welded to the inside of the door. Fronts shall be code gauge full-finished steel with rust inhibiting primer and baked enamel finished in ASA #49 gray. Panelboards installed in exterior or wet locations shall have NEMA 3R enclosures.

E. Each section of multi-section panelboards shall be of matching heights and depths.

F. Panelboard enclosures shall be furnished as shown on panel schedule on plans for surface, flush or motor control center mounting.

2.4 MANUFACTURER

A. Panelboards shall be as manufactured by Square 'D', G.E., Siemens or Cutler Hammer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All panelboard dimensions and clearances shall be carefully checked and coordinated with the proper trades to insure proper mounting space and support prior to roughing in equipment. In no case shall any circuit breaker be located above 6’-7” A.F.F..

B. Wiring in panelboard gutters shall be done in a neat and workmanlike manner. Wiring shall be grouped into neat bundles and secured with approved tie wraps.

3.2 PERFORMANCE TESTING

A. The ground-fault protection system when provided shall be performance tested after installation by a qualified person(s) using primary current injection in accordance with the instructions provided with the equipment and NEC requirements. A written record of the testing shall be provided.

B. The arc energy reduction protection system when provided shall be performance tested after installation by a qualified person(s) using primary current injection in accordance with the instructions provided with the equipment and NEC requirements. A written record of the testing shall be provided.

3.3 PANEL IDENTIFICATION

A. Refer to Specification Section 26 05 53.

END OF SECTION 26 24 16

SECTION 26 24 17

LIGHTING PANELBOARDS

PART 1 - GENERAL

1.1 GENERAL

A. The work under this section includes but is not limited to the following:
   1. Lighting Panelboards
   2. Circuit Breakers

PART 2 - PRODUCT

2.1 PANELBOARDS

A. Enclosure:
   1. Panelboards shall be dead front type and shall be in accordance with Underwriter's Laboratories, Inc., standard of panelboards and enclosing cabinets and so labeled.
   2. Panelboards installed in dry locations shall have enclosures fabricated from sheet steel and shall be finished in ASA #49. Panelboards installed in exterior or wet locations shall have NEMA 3R enclosures.
   3. The door shall have a cylinder type lock. Lock shall be held in place by concealed screw to a captive nut, welded to inside of door. All locks shall be keyed alike.
   4. A metal framed circuit directory card holder with clear plastic covering shall be factory-mounted on the inside of door.
   5. Panels for 20 or more circuits, including spares and spaces, shall be 20 inches wide.
   6. Panelboards enclosures shall be as shown on panel schedule on plans for surface, flush or motor control center mounting.
   7. Provide hinged trim with piano-hinge down full length of one side to allow access to wiring without complete removal of outer trim.
   8. Each section of multi-section panelboards shall be of matching heights and depths.

B. Bussing/Lugs:
   1. Ampacity and service voltage of main buss, lugs or main breakers and branch circuit breakers shall be as shown on drawings.
   2. All bussing and associated connectors shall be tin-plated copper.
   3. All panelboards shall contain ground buss.
   4. Entire panelboard shall be capable of withstanding a short circuit not less than the interrupting capacity of any breaker in the panel. When a power distribution system electrical study (including short circuit stud, etc.) is a part of the project, contractor shall further verify that all proposed equipment is properly rated (per the results of the study) prior to submitting shop drawings. Interrupting ratings shall be full ratings. Series ratings will not be allowed unless shown otherwise on drawings.
   5. Buss connectors shall be for distributed phase arrangement.
   6. Main and sub-feed lugs shall be provided with AL/CU compression lugs suitable for the quantities and sizes of conductors required.

7. Top/bottom feed arrangement and lug sizes/quantities shall be coordinated by the contractor.
8. Entire panelboard assembly, including all bussing, shall have SCCR ratings meeting or exceeding the minimum AIC ratings listed on the plans for the panel. When a power distribution system electrical study (including short circuit stud, etc.) is a part of the project, contractor shall further verify that all proposed equipment is properly rated (per the results of the study) prior to submitting shop drawings. All ratings shall be full ratings. Series ratings will not be allowed unless shown otherwise on drawings.
9. Service entrance panelboards shall be provided with barrier such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations

C. Breaker arrangement and numbering:
1. Panelboards shall be factory assembled with branch breakers arranged exactly as indicated on plans.
2. Breakers shall be numbered vertically beginning top left. Multi-section panelboards shall be numbered consecutively through all sections.
3. Breaker numbers shall be permanently attached to trim.
4. Main breakers shall be vertically-mounted (branch-mounted or back-fed main breakers will not be acceptable unless specifically so shown on plans).

2.2 CIRCUIT BREAKERS

A. Circuit breakers shall be quick break, quick make, thermal magnetic type, for alternating current. Breakers shall trip free for the handle and tripping shall be indicated by the handle assuming a position between OFF and ON.

B. Circuit breakers shall be of the bolt-on type.

C. Multi-pole breakers shall be internal common trip with single operating handle; external handle ties are not acceptable, unless specifically noted otherwise (such as for multi-wire branch circuits described below).

D. Circuit breakers feeding multiwire branch circuits (as defined by NEC) consisting of separate single phase loads sharing a common neutral shall be provided with multi-pole breakers or handle ties to simultaneously disconnect all ungrounded conductors per NEC Article 210.4(B). The necessary locations of these multi-pole breakers or handle ties shall be coordinated by the contractor. Where necessary, the contractor may rearrange circuit breakers (as minimally as possible) as required to meet this requirement.

E. All breakers shall meet the minimum RMS symmetrical interrupting capacity ratings shown on plans for the associated panel. All interrupting ratings shall be full ratings. Series ratings will not be allowed unless shown otherwise on drawings.

F. All branch circuit breakers shall be listed to UL489 or shall be specially-tested to be HACR listed.

2.3 SPECIAL REQUIREMENTS

A. Any special requirements on the drawings, such as for increased interrupting rating, ground fault protection, etc., shall supersede these specifications, but only insofar as that particular requirement is

concerned.

B. Lighting panels larger than 400A shall conform to the requirements for power panels.

2.4 MANUFACTURER

A. Panelboards shall be as manufactured by Square 'D', G.E., Siemens or Cutler Hammer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All panelboard dimensions and clearances shall be carefully checked and coordinated with the proper trades to insure proper mounting space and support prior to roughing in equipment. In no case shall any circuit breaker be located above 6'-7" A.F.F..

B. Wiring in panelboard wireways shall be done in a neat and workmanlike manner. Wiring shall be grouped into neat bundles and secured with approved tie wraps.

C. For all flush-mounted panelboards, a minimum of three (3) one-inch empty conduits shall be stubbed out above the nearest accessible ceiling space for future use.

3.2 PANEL IDENTIFICATION

A. Refer to Specification Section 26 05 53.

END OF SECTION 26 24 17

SECTION 26 27 13

ELECTRICAL METERING

PART 1 - DESCRIPTION

A. Electrical services shall be metered. Meters and instrument transformers used for metering services shall be revenue class equipment.

B. Services shall be metered at the building's power transformer(s). These meters are to be instrument rated, socket mounted, three element kWh meters mounted on a socket type meter base with test switches. The meter should be mounted on the side of the pad mounted transformer or transclosure. The meter of a 3P4W WYE service should be a type 9S as indicated below. The meter and base for services other than 3P4W should be similar.

PART 2 - PRODUCTS

2.1 SERVICE METERS

A. Service meters shall indicate energy usage in kWh and demand kW and maximum demand since it was last reset. The meter shall also indicate the voltage and current of all phases.

B. Manufacturer: Electrical meters shall be polyphase, form 9s, CL20, 120-480V, Elster A3RL with integrated Sensus FlexNet module. Battery and MeterCat program shall be loaded at the factory. Elster meters with Sensus FlexNet modules are provided by the University of Alabama.

2.2 SERVICE METER BASES

A. Service meter bases shall be an instrument rated ring-type unit with a 2-piece cover and lock-ring guards. It should also include ten (10) pre-wired test switches. The test switches from left to right are to be Pa-Ca+-Ca- -Pb-Cb+-Cb- -Pc-Cc+-Cc- -Pn-.

Manufacturer: Meter Devices Company, Inc.

Millbank Manufacturing, Inc.

Confirm all requirements for meter bases with the University of Alabama Project Manager prior to ordering.

2.3 SERVICE METER INSTRUMENT TRANSFORMERS

A. Instrument transformers are to be located in the padmounted transformer's secondary compartment for main building service metering. Current transformers (CT's) within the secondary compartment of padmounted transformers shall be mounted on the secondary bushings. CT's shall meet ANSI accuracy class with a factory standard ratio with the primary sized at approximately 1/2 to 3/4 of the service entrance capacity.

B. Instrument transformers for sub-metered services shall be located within an appropriately sized and approved CT cabinet. CT cabinets shall be a manufactured by Milbank of approved equal. CT's shall meet ANSI accuracy class with a factory standard ratio with the primary sized at approximately 1/2 to 3/4 of the feeder capacity.

PART 3 - EXECUTION

3.01 METER CABLING

A. Wiring between the instrument transformers and the meter shall be color-coded so that leads can be easily differentiated.

3.2 NETWORK CABLING

A. Include a 1" conduit between the secondary compartment of the service transformers and the building's electrical service room for installation of network cabling. The conduit should terminate into a wall mounted junction box located in a corner of the room.

END OF SECTION 26 27 13

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Wiring Devices

B. Plates

C. Finishes

PART 2 - PRODUCTS

2.1 WIRING DEVICES AND PLATES

A. Switches shall be AC type, extra-heavy duty industrial grade (unless otherwise shown) of ratings shown on drawings. Switches shall be as manufactured by Hubbell, P & S, Sierra, Bryant, GE, Arrow Hart or equal.

B. Receptacles shall have blade configuration and shall be heavy duty industrial grade (unless otherwise shown) of current and voltage rating as shown on drawings. Receptacles shall be as manufactured by Hubbell, P & S, Sierra, Bryant, GE, Arrow Hart or equal.

C. All GFCI-type receptacles shall continuously self-test and shall trip/deny power if the receptacle does not provide proper GFCI protection or if the line/load terminations are miswired and shall provide visual indication of power status, trip conditions, ground fault conditions and end-of-life status.

D. Each wiring device shall have a plate (see “Finishes” section below for specific requirements).

2.2 FINISHES

A. All wiring devices (switches, receptacles, etc.) shall be colored to match the coverplates described below. For instance, all items covered by stainless steel, aluminum or malleable iron plates shall be gray in color.
   1. Exceptions:
      a. Emergency wiring devices shall be red.
      b. Isolated ground wiring devices shall be orange.

B. Coverplates for recessed, wall-mounted electrical items (switches, receptacles, telephone outlets, etc.) shall be stainless steel unless shown otherwise.

C. Coverplates, trim rings, etc. for recessed, floor-mounted electrical items (floor outlets, underfloor duct junctions, etc.) shall match finish of building hardware (302/304 stainless steel, brass, etc.) in area installed.

D. Coverplates for exposed electrical items (switches, receptacles, telephone outlets, etc.) shall be of same

material as exposed boxes (see Outlet Box Specification for required material type) and shall have beveled edges.

E. Coverplates for receptacles in wet locations shall be metallic, in-use type, rated for wet locations per NEC requirements unless noted otherwise.

F. See “Electrical Identification” specification section for coverplate labeling requirements.

PART 3 - EXECUTION

3.1 GENERAL MOUNTING

A. Symbols on drawings and mounting heights are approximate. The exact locations and mounting heights shall be determined on the job, and it shall be the Contractor's responsibility to coordinate with all trades to secure correct installation. For example, Contractor shall coordinate exact mounting heights over counters, in or above backsplashes, in block walls, and at other specific construction features.

B. Verify all door swings with Architectural. Locate boxes for light switches within four inches of door trim on swing side (not hinge side) of door.

C. Devices and associated plates shall not be used as support; outlet boxes shall be rigidly supported from structural members.

D. Mount all straight-blade receptacles vertically with ground pole up, unless specifically noted otherwise.

E. Unless otherwise shown or required by local handicap codes, outlet boxes shall be the following distances above the finished floor unless otherwise noted.
1. Receptacles and telephone outlets in offices and other finished areas: 1’-6” to the center of the box.
2. Receptacles and telephone outlets in equipment rooms and other unfinished areas: 4’-0” to the center of the box.
3. Receptacles over counters: As Noted
4. Switches, general: 4’-0” to the top of the box.
5. Fire Alarm Pull Stations: 4’-0” to the top of the box.
6. Fire Alarm Audio/Visual Devices: As shown on fire alarm shop drawings (Entire lens shall be above 80” and below 96” per NFPA 72).
7. Push-button, etc., general: 4’-0” to the top of the box.
8. Other device types: verify with engineer prior to rough-in.

END OF SECTION 26 27 26

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 GENERAL

A. THE WORK UNDER THIS SECTION INCLUDES BUT IS NOT LIMITED TO THE FOLLOWING:
1. Fuses

PART 2 - PRODUCTS

2.1 FUSES

A. Fuses - 600 volts and less - shall be furnished and installed by electrical contractor who will maintain fuses in original new condition until installed. Fuses shall not be installed until equipment is ready to be energized.

B. Fuses 601 to 6000 amperes shall be time-delay, Class L type with an "O" ring to provide seal between the end bells and the glass melemine fuse barrel. Terminals shall be penned. Fuses must hold 500% rating for a minimum of 4 seconds and clear 20 times rated current in .01 seconds or less. Fuses shall be current-limiting and be listed by Underwriters Laboratories, Inc. with an interrupting rating of 200,000 amperes r.m.s. symmetrical. Bussmann Hi-Cap, time-delay, Class L fuses.

C. All other fuses for power, light and motor circuits shall be dual-element, Class RK5 type with separate overload and short-circuit elements. The overload element shall incorporate a spring activated thermal unit having a 284 Degree Fahrenheit melting point alloy and with a heat sink that will provide time-delay of a minimum of 10 seconds at 500% rating. Fuses shall be current-limiting and be listed by Underwriters Laboratories, Inc. with an interrupting rating of 200,000 amperes r.m.s. symmetrical. Bussmann Low-Peak, dual-element, Class RK5 fuses.

D. Fuses shall be installed in fluorescent fixtures on the line side of the ballast by the fixture manufacturer who will size the fuses for each application. Bussmann GLR fuses installed in HLR fuseholder.

E. Fuses for all other ballast-controlled lighting fixtures shall have fuses installed on the line side of the ballast either in the housing or handhole of lighting standards for easy access. Bussmann FNQ fuse with HPF holder for all applications. Bussmann FNQ fuse with HPF holder for all applications except lighting Standards where Bussmann HEB-JJ holder with FNQ fuse will be used.

2.2 MANUFACTURER

A. Fuses shall be as manufactured by Bussmann Manufacturing or approved equal. Approved substitutions will be allowed that provide required electrical safety overload and short-circuit performance. Electrical contractor shall submit one copy each of fuse and fuse holder manufacturers bulletins that fully describe performance for substitution approval consideration. The bulletins shall be submitted to the Electrical Design Engineer at time of bid submittal.

PART 3 - EXECUTION

3.1 SPARE FUSES

A. Spare fuses shall be provided by the electrical contractor. 10% (minimum of 3) of each size and type will be placed in a Spare Fuse Cabinet mounted on the wall of the electrical room.

END OF SECTION 26 28 13

SECTION 26 28 16

SAFETY SWITCHES AND FUSES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Safety Switches

B. Fuses

C. Branch Feeders

D. Feeders

PART 2 - PRODUCTS

2.1 SAFETY SWITCHES

A. Safety switches shall be quick-make, quick-break, NEMA heavy duty type HD, fused or nonfused as shown. Switch blades shall be fully visible in the off position.

B. Safety switches shall be furnished with transparent internal barrier kits to prevent accidental contact with live parts. Barriers shall provide finger-safe protection when the switch door is open and shall allow use of test probes and removal of fuses without removing barrier.

C. Fused switches shall have provisions for class R, rejection type fuses.

2.2 FUSES (600V)

A. Fuses for all branch switches shall be Bussman Mfg. Co., Dual Element, Class “R” Fusetron.

B. Fuses for main switch/switches shall be Bussman Mfg. Co. Hi-Cap.

2.3 MANUFACTURER

A. Safety switches shall be as manufactured by Square 'D', G.E., Siemens or Cutler Hammer.

B. Fuses shall be as manufactured by Bussman Mfg. Co. or equal.

PART 3 - EXECUTION

3.1 SAFETY SWITCHES

A. Safety switches shall be installed as shown on the plans and in accordance with N.E.C.

B. Locations shown for safety switches on plans are diagrammatical only. Exact locations shall be field coordinated by contractor as required to provide code-required clearances.

C. Switch enclosures shall be rated NEMA I indoors in dry locations and NEMA3R outdoors and in wet areas.

D. Adequate support shall be provided for mounting safety switches. Safety switches shall not be mounted to the associated equipment (unless the safety switch is furnished with the equipment).

3.2 FUSES

A. Fuses shall be sized as shown on drawings, unless a smaller size is required by the associated equipment supplier, in which case the contractor shall provide fuses sized as directed by the associated equipment supplier at no additional cost.

B. Provide not less than one spare set of fuses for each size used. Provide an additional spare set for each five sets of same size fuses used.

END OF SECTION 26 28 16

SECTION 26 32 13

GENERATOR SETS

PART 1 - GENERAL

1.1 SCOPE

A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator.

B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.

C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1.2 CODES AND STANDARDS

A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of the latest editions of the following standards/codes where applicable:
1. CSA 282, 1989 Emergency Electrical Power Supply for Buildings
2. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
3. International Building Codes.
4. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
5. NFPA99 – Essential Electrical Systems for Health Care Facilities.
6. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

B. The generator set and supplied accessories shall meet the requirements of the latest editions of the following standards where applicable:
1. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
2. UL142 – Sub-base Tanks
3. UL1236 – Battery Chargers
4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.

C. The generator set and supplied accessories shall meet all applicable Environmental Protection Agency (EPA) TIER Emission Level or Emission Certification requirements and any local requirements in effect at the time the generator set is ordered (for the proposed location of the generator).

D. The control system for the generator set shall comply with the following requirements.
   1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
   2. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
   3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
   4. FCC Part 15, Subpart B.
   5. IEC8528 part 4. Control Systems for Generator Sets
   6. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
   7. UL508. The entire control system of the generator set shall be UL508 listed and labeled.
   8. UL1236 –Battery Chargers.

E. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.3 ACCEPTABLE MANUFACTURERS

A. Caterpillar

B. Cummins/Onan

C. Generac

D. Kohler

PART 2 - PRODUCTS

2.1 GENERATOR SET

A. Ratings
   1. The generator set assembly (including both the motor/engine assembly and the generator assembly) shall operate at 1800 rpm, and the generator shall produce a 60 Hz waveform.
   2. Voltage and phase ratings shall be as shown on plans.
   3. Minimum kW rating (and associated alternator sizing) shall be the greater of the following:
      a. Minimum kW rating listed on plans.
      b. Ratings required to provide skVA as follows (shall be documented with reports in submittals using generator sizing software described in Part 3 below):
         1) If so listed on plans, the step loads fed by the generator at voltage/frequency dip criteria specified.
         2) If so listed on plans, the skVA rating specified.
         3) If neither of the above are listed on plans, generator shall be sized to accommodate a block load of 100% of the Total Demand Load listed on plans, with a maximum voltage dip of 20% and a maximum frequency dip of 10%.
   4. kVA rating shall be 1.25 times the kW rating (based on .8 PF).
   5. Unless shown otherwise on plans, the generator set shall be rated based on the following site conditions:
      a. Altitude of project site.

b. Ambient temperatures up to 120 degrees F.

6. The generator set rating shall be based on emergency/standby service unless noted otherwise.

B. Performance

1. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.
3. The engine-generator set shall be capable of accepting a single step load of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
4. Minimum motor starting capability shall be as shown on plans. The generator set shall be capable of recovering to a minimum of 90% of rated no load voltage following the application of the specified skVA load at near zero power factor applied to the generator set. Maximum voltage dip on application of this load, considering both alternator performance and engine speed changes shall not exceed 20% unless shown otherwise on plans.
5. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.
6. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.

C. Construction

1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
2. The engine-generator set shall be rated for the seismic conditions for the installation location as mapped by the US Geological Survey and required by local building codes.
3. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. All active control components shall be installed within a UL/NEMA 3R enclosure. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

D. Connections

1. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept compression terminations of the number and size as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.
2. Power connections to auxiliary devices shall be made at the devices, with required overcurrent protection located at panelboard(s) external to the generator set unless shown otherwise on plans. Where a load center or panelboard is shown within the generator enclosure on the plans, this load center/panelboard shall be furnished with the generator and shall comply with the applicable panelboard and identification sections of this specification.

3. Generator set control interfaces to other system components shall be made on a permanently labeled terminal block assembly. Labels describing connection point functions shall be provided.

2.2 ENGINE AND ENGINE EQUIPMENT

A. The engine shall be natural gas fueled, radiator and fan cooled. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:
1. Complete engine fuel system, including all pressure regulators, strainers, and control valves. The fuel system shall be plumbed to the generator set skid for ease of site connections to the generator set. For dual fuel systems, changeover from primary to secondary fuel shall be automatic.
2. An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed and operating in various isochronous or parallel states. The governing system shall include a programmable warm up at idle and cooldown at idle function. While operating in idle state, the control system shall disable the alternator excitation system.
3. Skid-mounted radiator and cooling system rated for full load operation in 120 degrees F (49 degrees C) ambient as measured at the generator air inlet. Radiator fan shall be suitable for use in a system with 0.5 in H_2O restriction. Radiator shall be sized based on a core temperature that is 20F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture prior to shipping. Rotating parts shall be guarded against accidental contact.
4. Electric starter(s) capable of three complete cranking cycles without overheating.
5. Positive displacement, mechanical, full pressure, lubrication oil pump.
6. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
7. Replaceable dry element air cleaner with restriction indicator.
8. Flexible fuel lines.
9. Engine mounted battery charging alternator and solid-state voltage regulator.
10. Block heater
    a. Engine mounted, thermostatically controlled, block heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
    b. The block heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The block heater installation shall be specifically designed to provide proper venting of the system. The block heaters shall be installed using quick disconnect couplers to isolate the heaters for replacement of the heater element without draining the coolant from the generator set. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.

c. The block heater shall be provided with a DC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the block heater system.
d. The block heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 104F (40C) in a 40F (4C) ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification. If the heater quantities or wattage ratings are different than shown on plans, contractor shall be responsible for providing the properly-rated circuits (with circuit breakers) as required to the heater(s).

11. Provide vibration isolators, spring & pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
12. Starting and Control Batteries shall be calcium/lead antimony type, 24 volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors. The batteries shall be capable of a minimum of three complete 15-second cranking cycles at 40F ambient temperature when fully charged.
13. Provide critical-grade exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer. Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.
14. A UL listed/CSA certified voltage regulated battery charger shall be provided for each engine-generator set. The charger shall be located at the generator unless shown otherwise on plans. Output amperage, Input AC voltage and DC output voltage shall be as required. Chargers shall be equipped with float, taper and equalize charge settings. Charger shall include an Analog DC voltmeter and ammeter, 12 hour equalize charge timer, and AC and DC fuses. Operational monitors shall provide visual output along with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of:
    a. Loss of AC power - red light
    b. Low battery voltage - red light
    c. High battery voltage - red light
    d. Power ON - green light and N.O. relay contact
15. Provide 120 volt battery warmer with automatically controlled thermostat.

2.3 AC GENERATOR

A. The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system and shall be UL1446 listed. Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees Centigrade.

B. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

C. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.

D. AC generator shall be 12-lead reconnectable type to provide the following voltage output configurations:
1. 277/480V-3Phase-4Wire
2. 120/208V-3Phase-4Wire
3. 120/240V-3Phase-4Wire
4. 120/240V-1Phase-3Wire

E. The subtransient reactance of the alternator shall not exceed 12 percent, based on the standby rating of the generator set.

2.4 GENERATOR SET CONTROL

A. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

B. The control shall be mounted on the generator set, or may be mounted in a free-standing panel next to the generator set if adequate space and accessibility is available. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

C. The generator set mounted control shall include the following features and functions:
1. Control Switches
   a. Mode Select Switch. The mode select switch shall initiate the following control modes. When in the RUN or MANUAL position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
   b. The integrity of the generator remote start circuit shall be monitored for broken, disconnected or shorted wires. Loss of integrity shall start the generator.
   c. EMERGENCY STOP switch. Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
   d. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
   e. PANEL LAMP switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
2. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
   a. Analog voltmeter, ammeter, frequency meter, power factor meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Meter scales shall be color coded in the following fashion: green shall indicate normal operating condition, amber shall indicate operation in ranges that indicate potential failure, and red shall indicate failure impending. Metering accuracy shall be within 1% at rated output.
   b. The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10%

increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.

c. The control system shall log total number of operating hours, total kWH, and total control on hours, as well as total values since reset.

3. Generator Set Alarm and Status Display.
   a. The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright exterior day lighting conditions.
   b. The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. Conditions required to be annunciated shall include:
      1) low oil pressure (warning)
      2) low oil pressure (shutdown)
      3) oil pressure sender failure (warning)
      4) low coolant temperature (warning)
      5) high coolant temperature (warning)
      6) high coolant temperature (shutdown)
      7) high oil temperature (warning)
      8) engine temperature sender failure (warning)
      9) low coolant level (warning or shutdown - selectable)
      10) fail to crank (shutdown)
      11) fail to start/overcrank (shutdown)
      12) overspeed (shutdown)
      13) low DC voltage (warning)
      14) high DC voltage (warning)
      15) weak battery (warning)
      16) high AC voltage (shutdown)
      17) low AC voltage (shutdown)
      18) under frequency (shutdown)
      19) over current (warning)
      20) over current (shutdown)
      21) short circuit (shutdown)
      22) ground fault (warning) (if genset breaker is rated 1000A or greater)
      23) over load (warning)
      24) Genset circuit breaker tripped (warning)
      25) emergency stop (shutdown)
4. Engine Status Monitoring.
   a. The following information shall be available from an analog status panel on the generator set control :
      1) engine oil pressure (psi or kPA)
      2) engine coolant temperature (degrees F or C)
      3) battery voltage (DC volts)
5. Engine Control Functions.
   a. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

b. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
c. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
d. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
e. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

6. Alternator Control Functions:
   a. The generator set shall include an automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, with local indication of setting level.
   b. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.
   c. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445. This protection may be provided using a microprocessor-based programmable relay system designed to protect the alternator system from damage, or using programmable electronic-trip LSI breaker(s), programmed/set by the generator supplier to ensure full protection of the alternator system.
   d. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
   e. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when

alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

f. When required by National Electrical Code or indicated on project drawings, the control System shall include a ground fault monitoring relay. The relay shall be adjustable from 3.8-1200 amps, and include adjustable time delay of 0-10.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay that will function correctly in system as installed.

7. Other Control Functions
   a. The generator set shall communicate with the Automatic Transfer Switch via hardwired control connections as required.
   b. The integrity of the generator remote start circuit shall be monitored for broken, disconnected or shorted wires. Loss of integrity shall start the generator.
   c. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is out of acceptable limits. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

2.5 GENERATOR REMOTE ANNUNCIATOR

A. Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems for the local generator control panel. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 requirements.

B. Provide engraved nameplate at annunciator panel indicating associated generator name.

C. The interconnecting wiring between the annunciator and other system components shall be monitored and failure of the interconnection between components shall be displayed on the annunciator panel. Transient Voltage Surge Suppression shall be provided on both ends of any interconnecting wiring (between the annunciator and other system components) that extends outside of a building.

D. The annunciator shall include the following alarm labels, audible annunciation features, and lamp colors:

Condition	Lamp Color	Audible Alarm
Normal Power (to Loads)	Green	No
Genset Supplying Load	Amber	No
Genset Running	Green	No
Not in Auto	Red (Flashing)	Yes

Emergency Stop	Red (Flashing)	Yes
Genset CB tripped/off	Red (Flashing)	Yes
Low Battery Voltage	Red	Yes
Charger AC Failure	Red	Yes
Fail to Start	Red	Yes
Low Engine Temperature	Amber	Yes
Pre-High Engine Temperature	Amber	Yes
High Engine Temperature	Red	Yes
Pre-Low Oil Pressure	Amber	Yes
Low Oil Pressure	Red	Yes
Overspeed	Red	Yes
Low Coolant Level	Amber	Yes
Low Fuel Level	Amber	Yes
Network OK	Green	Yes
Other conditions as required by NFPA 110	As Required	As Required
(2) Spares	Configurable	Configurable

2.6 GENERATOR REMOTE MANUAL STOP STATION

A. Each generator set shall be furnished with a remote manual stop station of a type to prevent inadvertent or unintentional operation per NFPA 110 requirements.

B. Stop station pushbutton shall be red, non-illuminated, push-pull, mushroom-type, maintained-contact, 1 5/8" diameter, 30mm base, heavy-duty, oil-tight, water-tight unit) mounted within guarded enclosure to prevent inadvertent operation and labeled with engraved nameplate (white letters on red background) to read: "GENERATOR EMERGENCY STOP" (or similar with specific generator name where so identified on drawings).

C. Exact stop station type shall be coordinated with generator controls supplier to ensure a fully-functional system per NFPA 110 requirements.

2.7 GENERATOR MAIN LINE CIRCUIT BREAKER(S)

A. The generator set shall be provided with a mounted main line circuit breaker(s), sized as shown on plans. The circuit breaker(s) shall incorporate an electronic trip unit that operates to protect the alternator under all overcurrent conditions, or a thermal-magnetic trip with other overcurrent protection devices that positively protect the alternator under overcurrent conditions. The supplier shall submit time overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided.

B. The main line circuit breaker(s) shall be provided with auxiliary contacts to indicate trip/off alarm conditions to the generator set control system.

2.8 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. The generator set shall be provided with a weatherproof, sound-attenuated, outdoor enclosure, with the

entire package listed under UL2200. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank (if applicable) shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100F. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

B. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 76 dBA (including exhaust noise) at any location 7 meters from the generator set in a free field environment:

C. The enclosure shall include vertical air discharge hoods as required to redirect discharge air upwards and reduce noise accordingly.

D. The enclosure shall be insulated with non-hydroscopic materials.

E. The enclosure shall be rated for the wind and seismic conditions for the installation location as mapped by the US Geological Survey and required by local building codes.

F. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturers standard color using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:
   1. Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.
   2. Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.
   3. Crosshatch adhesion, per ASTM D3359-93, 4B-5B.
   4. Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.
   5. Salt Spray, per ASTM B117-90, 1000+ hours.
   6. Humidity, per ASTM D2247-92, 1000+ hours.
   7. Water Soak, per ASTM D2247-92, 1000+ hours.

G. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.

H. Enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. All hardware and hinges shall be stainless steel.

I. A factory-mounted critical exhaust silencer shall be installed inside the enclosure. The exhaust shall exit the enclosure through a rain collar and terminate with a rain cap. Exhaust connections to the generator set shall be through seamless flexible connections.

J. The enclosure shall include the following maintenance provisions:

1. Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
2. External radiator fill provision.

K. If so shown on the plans, provide a factory-mounted and wired electrical distribution panel to serve the generator set and enclosure. The provisions required include:
1. 100-amp distribution panelboard installed inside enclosure and fed by a 120/208VAC power feeder installed by the contractor (unless shown otherwise on plans).
2. Two duplex GFI receptacles, one inside the enclosure, and a weatherproof receptacle on the outside of the enclosure (all factory-wired).
3. Two three-way switches controlling three AC lamps mounted in vapor tight and gasketted fixtures (all factory-wired).
4. Factory-wired normal AC service from the panelboard to the engine coolant and alternator heaters, and battery charger.

2.9 SEQUENCE OF OPERATION

A. The maximum elapsed time allowed from loss of normal power to restoration of power to emergency circuits from generator through transfer switch shall be 10 seconds.

B. Generator set shall start upon receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control.
1. The integrity of the generator remote start circuit shall be monitored for broken, disconnected or shorted wires. Loss of integrity shall start the generator.

C. The generator set shall complete a time delay start period as programmed into the control.

D. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
1. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate “fail to crank” shutdown.
2. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.
3. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
4. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous, synchronize, load share, load demand or load govern state.

E. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.

F. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.

G. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

PART 3 - EXECUTION

3.1 SUBMITTALS.

A. Within 10 days after award of contract, provide six sets of the following information for review:
1. Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
2. Where generator is to be fed from a dedicated natural gas fuel service, a letter from the utility source acknowledging availability of the necessary gas service along with all associated requirements of the utility provider.
3. A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
4. Manufacturer's certification of prototype testing.
5. Manufacturer's published warranty documents.
6. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
7. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
8. Generator sizing software report(s) showing compliance with all specification requirements and any additional motor starting requirements indicated in contract documents.
9. Time-current-curves demonstrating that the generator alternator relaying or breaker protective device(s) provide proper protection for the alternator by a comparison of the trip characteristic of the breaker with the thermal damage characteristic of the alternator.
10. Manufacturer's installation instructions.

3.2 FACTORY TESTING.

A. The generator set supplier shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. Equipment supplied shall be fully tested at the factory for function and performance.

B. Factory testing may be witnessed by the owner and consulting engineer. Costs for travel expenses will be the responsibility of the owner and consulting engineer. Supplier is responsible to provide two weeks notice for testing.

C. Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.

3.3 INSTALLATION

A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions

included in the listing or labeling of UL listed products.

B. Installation of equipment shall include furnishing and installing all interconnecting wiring, fuel lines, etc. between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.

C. Generator equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and seismic requirements of the site.

D. Contractor shall be responsible for coordinating (prior to providing submittal data) and providing complete engine fuel system, including gas service from the local gas utility company, all piping, pressure regulators, strainers, control valves, etc. as required for a fully-functional, code-compliant fuel system. Entire installation shall be provided in strict conformance with all recommendations and requirements of the generator manufacturer. All costs (including aid-to-construction costs from the local gas company where the generator is to be fed directly from a dedicated natural gas service) shall be included in bid cost. The fuel system shall be plumbed to the generator set skid for ease of site connections to the generator set.

E. Remote stop station type, labeling and location shall be submitted by contractor to engineer and local fire marshal for approval prior to rough-in. Location shall be outside the room housing the prime mover (where so installed within a room) or elsewhere on the premises where the prime mover is located outside the building. Contractor shall provide all interconnections from remote stop station to generator set as required by generator set supplier for a fully-functional system.

F. Equipment shall be initially started and operated by representatives of the manufacturer.

G. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.

3.4 ON-SITE ACCEPTANCE TEST:

A. The complete installation shall be tested for compliance with the specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests.

B. Installation acceptance tests to be conducted on-site shall include the following (performed in accordance with NFPA 110):
   1. "Cold start" test.
   2. Four (4) hour full load test. Provide resistive load banks and make temporary connections as required.
   3. One step rated load pickup test.
   4. Power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

3.5 TRAINING

A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to not less than 5 persons. Training date shall be coordinated with the facility owner.

3.6 SERVICE AND SUPPORT

A. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.

B. The generator set shall be distributed and serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.

C. The manufacturer of the generator set shall own, maintain and make available (to engineer, free of charge) generator set sizing software that calculates voltage dip, frequency dip, THDI and THDV of proposed generator/alternator set using the following inputs:
1. Summary of step loads including load type (across-the-line motor, VFD, Fire Pump, Fluorescent Lighting, UPS, etc.).
2. Generator Set Duty (Standby, Prime, Continuous).
3. Maximum Ambient Temperature.
4. Project site altitude.
5. Generator Fuel type.
6. Voltage/Phase/Frequency.

D. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

3.7 WARRANTY

A. The generator set and associated equipment shall be warranted for a period of not less than 2 years from the date of commissioning against defects in materials and workmanship.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

END OF SECTION 26 32 13

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SCOPE

A. Provide complete factory assembled power transfer equipment with field programmable digital electronic controls designed for fully automatic operation and including: voltage sensors on all phases of both sources, power switch mechanism, permanently attached manual operation provisions, positive mechanical and electrical interlocking, and mechanically held contacts for both sources.

B. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for all the products provided. Technicians specifically trained to support the product shall service the transfer switches.

1.2 CODES AND STANDARDS

A. The automatic transfer switch installation and application shall conform to the requirements of the following codes and standards:
1. CSA 282, Emergency Electrical Power Supply for Buildings
2. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
3. NFPA99 – Essential Electrical Systems for Health Care Facilities
4. NFPA110 – Emergency and Standby Power Systems. The transfer switch shall meet all requirements for Level 1 systems.
5. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
6. NEMA ICS10-1993 – AC Automatic Transfer Switches.

B. The transfer switch assembly shall comply with the following standards:
1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
2. EN55011, Class B Radiated Emissions
3. EN55011, Class B Conducted Emissions
4. IEC 1000-4-5 (EN 61000-4-5); AC Surge Immunity.
5. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
6. IEC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
7. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
8. IEC 1000-4-6 Conducted Field Immunity
9. IEC 1000-4-11 Voltage Dip Immunity.
10. IEEE 62.41, AC Voltage Surge Immunity.
11. IEEE 62.45, AC Voltage Surge.
12. UL1008 – Transfer Switches. Transfer switches shall be UL1008 (latest edition) listed. UL1008 transfer switches may be supplied in UL891 enclosures if necessary to meet the physical requirements of the project.

C. The transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and shall

have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.3 ACCEPTABLE MANUFACTURERS

A. Cummins/Onan

B. Caterpillar

C. Generac

D. Kohler

E. Zenith

F. Russelectric

G. ASCO

H. Eaton

PART 2 - PRODUCTS

2.1 POWER TRANSFER SWITCH

A. Ratings
1. Refer to the project drawings for specifications on the sizes and types of transfer switch equipment, withstand and closing ratings, voltage and ampere ratings, enclosure type, and accessories.
2. Main contacts shall be rated for 600 Volts AC minimum.
3. Transfer switches shall be rated to carry 100 percent of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 degrees C, relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000M).
4. Transfer switch equipment shall have withstand and closing ratings (WCR) in RMS symmetrical amperes equal to or greater than the required ratings shown on the drawings (at the specified voltage). The transfer switch shall be third party listed and labeled for use with the specific protective device(s) (both normal and emergency) installed in the application. All rating information including associated overcurrent devices shall be submitted with shop drawings. Where WCR is dependent on setting of upstream overcurrent device, transfer switch shall be field marked with the required settings of the associated device. When a power distribution system electrical study (including short circuit stud, etc.) is a part of the project, contractor shall further verify that all proposed equipment is properly rated (per the results of the study) prior to submitting shop drawings. The transfer switch and its upstream protection shall be coordinated.

B. Construction
1. Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the source 1 and source 2 positions. The transfer switch shall be specifically designed to transfer to the best available source if it inadvertently stops in a neutral position.

2. Transfer switches shall be of the Open Transition type. Transfer switches rated through 1000 amperes shall be equipped with permanently attached manual operating handles and quick-break, quick-make over-center contact mechanisms. Transfer switches over 1000 amperes shall be equipped with manual operators for service use only under de-energized conditions.
3. Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.
4. All wiring shall be UL listed 105 degree C, 600 volt rated, and sized as required. Each wire, device or function shall be identified with a source and destination by silk-screen or similar permanent identification. Circuit boards shall be connected wiring harnesses by means of locking disconnect plug(s), to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism.
5. Bus structures shall be constructed from silver plated copper or tin plated aluminum with bolted joints for all three phases, with a full neutral, and a 1/4 x 2 inch ground bus extending through all sections.
6. The framework and all other sheet metal components of the system shall be primed with a rust-inhibiting primer, and finished with two coats of satin finish ANSI 61 gray enamel, or manufacturer's standard color.
7. All door mounted control components shall be industrial type oil-tight devices with contact ratings a minimum of twice the maximum circuit ampacity they are controlling. Toggle switches and other light duty and durability control devices are not acceptable. Indicator lamps shall be high intensity LED type devices. Indicator lamp condition (on or off) shall be easily visible in bright room lighting conditions.
8. Power transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation or shall be indicated by mechanical flags. Barriers shall be provided to prevent inadvertent contact with any voltage of greater than 50VDC.
9. Transfer switches shall be 3-pole with a solid neutral bus and lugs. The neutral bus shall be sized to carry 100% of the current designated on the switch rating.

C. Connections
1. Field control connections shall be made on a common terminal block that is clearly and permanently labeled.
2. Transfer switch shall be provided with AL/CU compression lugs suitable for the quantities and sizes of power conductors required.

2.2 TRANSFER SWITCH CONTROL

A. Operator Panel. Each transfer switch shall be provided with a control panel to allow the operator to view the status and control operation of the transfer switch. The operator panel shall be permanently labeled for switch and control functions. The operator panel shall be provided with the following features and capabilities.
1. High intensity LED lamps to indicate the source that the load is connected to (source 1 or source 2); and which source(s) are available. Source available LED indicators shall operate from the control microprocessor to indicate the true condition of the sources as sensed by the control.
2. High intensity LED lamps to indicate that the transfer switch is "not in auto" (due to control being disabled or due to bypass switch (when used) enabled or in operation) and "Test/Exercise Active" to indicate that the control system is testing or exercising the generator set.

3. "OVERRIDE" pushbutton to cause the transfer switch to bypass any active time delays for start, transfer, and retransfer and immediately proceed with its next logical operation.
4. "TEST" pushbutton to initiate a preprogrammed test sequence for the generator set and transfer switch. The transfer switch shall be programmable for test with load or test without load.
5. "RESET/LAMP TEST" pushbutton that will clear any faults present in the control, or simultaneously test all lamps on the panel by lighting them.
6. The control system shall continuously log information on the number of hours each source has been connected to the load, the number of times transferred, and the total number of times each source has failed. This information shall be available via an operator display panel.
7. Vacuum fluorescent alphanumeric display panel with push-button navigation switches. The display shall be clearly visible in both bright (sunlight) and no light conditions. It shall be visible over an angle of at least 120 degrees. The Alphanumeric display panel shall be capable of providing the following functions and capabilities:
    a. Display source condition information, including AC voltage for each phase of normal and emergency source, frequency of each source. Voltage for all three phases shall be displayed on a single screen for easy viewing of voltage balance. Line to neutral voltages shall be displayed for 4-wire systems.
    b. Display source status, to indicate source is connected or not connected.
    c. The display panel shall allow the operator to view and make the following adjustments in the control system, after entering an access code:
        1) Set nominal voltage and frequency for the transfer switch.
        2) Adjust voltage and frequency sensor operation set points.
        3) Set up time clock functions.
        4) Set up load sequence functions.
        5) Enable or disable control functions in the transfer switch, including program transition.
        6) Set up exercise and load test operation conditions, as well as normal system time delays for transfer time, time delay start, stop, transfer, and retransfer.
    d. Display Real time Clock data, including date, and time in hours, minutes, and seconds. The real time clock shall be incorporate provisions for automatic daylight savings time and leap year adjustments. The control shall also log total operating hours for the control system.
    e. Display service history for the transfer switch. Display source connected hours, to indicate the total number of hours connected to each source. Display number of times transferred, and total number of times each source has failed.
    f. Display fault history on the transfer switch, including condition, and date and time of fault. Faults to include controller checksum error, low controller DC voltage, ATS fail to close on transfer, ATS fail to close on retransfer, battery charger malfunction, network battery voltage low, network communications error.

B. Internal Controls
1. The transfer switch control system shall be configurable in the field for any operating voltage level up to 600VAC. Provide RMS voltage sensing and metering that is accurate to within plus or minus 1% of nominal voltage level. Frequency sensing shall be accurate to within plus or minus 0.2%. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.

2. Transfer switch voltage sensors shall be close differential type, providing source availability information to the control system based on the following functions:
    a. Monitoring all phases of the normal service (source 1) for under voltage conditions (adjustable for pickup in a range of 85 to 98% of the normal voltage level and dropout in a range of 75 to 98% of normal voltage level).
    b. Monitoring all phases of the emergency service (source 2) for under voltage conditions (adjustable for pickup in a range of 85 to 98% of the normal voltage level and dropout in a range of 75 to 98% of pickup voltage level).
    c. Monitoring all phases of the normal service (source 1) and emergency service (source 2) for voltage imbalance.
    d. Monitoring all phases of the normal service (source 1) and emergency service (source 2) for loss of a single phase.
    e. Monitoring all phases of the normal service (source 1) and emergency service (source 2) for phase rotation.
    f. Monitoring all phases of the normal service (source 1) and emergency service (source 2) for over voltage conditions (adjustable for dropout over a range of 105 to 135% of normal voltage, and pickup at 95-99% of dropout voltage level).
    g. Monitoring all phases of the normal service (source 1) and emergency service (source 2) for over or under frequency conditions.
3. The transfer control shall incorporate a series of diagnostic LED lamps.
4. The transfer switch shall be configurable to control the operation time from source to source (program transition operation). The control system shall be capable of enabling or disabling this feature, and adjusting the time period to a specific value. A phase band monitor or similar device is not an acceptable alternate for this feature.The transfer switch shall incorporate adjustable time delays for generator set start (adjustable in a range from 0-15 seconds); transfer (adjustable in a range from 0-120 seconds); retransfer (adjustable in a range from 0-30 minutes); and generator stop (cooldown) (adjustable in a range of 0-30 minutes).
5. The transfer switch shall be configurable to accept a relay contact signal from an external device to prevent transfer to the generator service.
6. The control system shall be designed and prototype tested for operation in ambient temperatures from -40C to +70C. It shall be designed and tested to comply with the requirements of the noted voltage surge and RFI/EMI standards.
7. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs, and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.

C. Control Interface
1. The transfer switch shall provide an isolated relay contact for starting of a generator set. The relay shall be normally held open, and close to start the generator set. Output contacts shall be form C, for compatibility with any generator set.
2. The integrity of the generator remote start circuit shall be monitored for broken, disconnected or shorted wires. Loss of integrity shall start the generator.
3. Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 amps 250 VAC.
4. The transfer switch shall provide additional relay contacts to indicate the following conditions: Utility Source Available, Load Connected to Utility, Generator Source Available, Load Connected to Generator, Pre-Transfer Warning (adjustable 0-59 second time delay).

2.3 ENCLOSURE

A. Enclosures shall be UL listed. The enclosure shall provide wire bend space in compliance to the latest version of NFPA70. The cabinet door shall include permanently mounted key type latches.

B. If not specifically indicated otherwise on plans, transfer switch equipment enclosures shall meet the following minimum requirements:
   1. For dry interior locations: NEMA 1 or better (unless shown otherwise on plans).
   2. For wet interior (pump stations, etc.) or exterior locations: NEMA 3R or better (unless shown otherwise on plans).

C. The cabinet shall provide code-required wire bend space at point of entry as shown on the drawings. Manual operating handles and all control switches (other than key-operated switches) shall be accessible to authorized personnel only by opening the key-locking cabinet door. Transfer switches with manual operating handles and/or non key-operated control switches located on outside of cabinet do not meet this specification and are not acceptable.

D. Note size and access requirements for the transfer switch (and associated equipment) and provide equipment that will fit into the space allowed and comply with code-specified access requirements.

2.4 BATTERY CHARGING

A. The transfer switch/generator set combination shall be provided with a battery charger for the generator set starting batteries. Refer to Generator Sets Specification Section 26 32 13 for specific requirements. Supply power failed indication shall be displayed on the ATS control panel.

2.5 SEQUENCE OF OPERATION

A. Open Transition Sequence of Operation
   1. Normal State:
      a. Transfer switch normally connects an energized utility power source (source 1) to loads and a generator set (source 2) to the loads when normal source fails. The normal position of the transfer switch is connected to source 1 (connected to the utility), and no start signal is supplied to the genset.
   2. Normal Power Failure and Restoration:
      a. When the transfer switch senses a power failure on source 1, it shall complete a pre-programmed time delay start sequence, and then send a start signal to the generator set.
      b. The generator set shall immediately start and accelerate to rated voltage and frequency.
      c. The transfer system shall complete a programmable time delay sequence, and then transfer to source 2 by open transition. Generator set starting time and all time delays in the system are to be coordinated to allow the generator set to start and accept emergency loads within 10 seconds, unless specific exception is granted by the engineer.
      d. On return of source 1 to acceptable voltage and frequency levels, the control system shall initiate a time delay retransfer sequence. On completion of the time delay sequence, The control system shall transfer loads back to source 1 in the reverse sequence to that which was used to connect loads to source 2.
      e. If the generator set fails during this period and normal source is available, the transfer switch shall automatically reconnect the system loads to the normal service.
      f. The transfer switch shall operate the generator set unloaded for a cooldown period, and then remove the start signal from the generator set.

3. Generator Set Exercise (Test) With Load Mode (Open Transition). The control system shall be configurable to test the generator set under load. In this mode, the transfer switch shall control the generator set in the following sequence:
   a. Transfer switch shall initiate the exercise sequence at a time indicated in the exercise timer program, or when manually initiated by the operator.
   b. The transfer switch shall issue a compatible start command to the generator set as follows:
      1) On generators rated 50kW and greater, the transfer switch shall cause the generator set to start and run at idle until it has reached normal operating temperature. When the generator set has reached normal operating temperature or after an adjustable time period (whichever is shorter), the control system shall accelerate the generator set to rated voltage and frequency.
      2) On generators rated less than 50kW, the generator set shall immediately start and accelerate to rated voltage and frequency.
   c. When the control systems senses the generator set at rated voltage and frequency, it shall operate to connect the loads to the generator set by opening the normal source contacts, and closing the alternate source contacts a predetermined time period later. The timing sequence for the contact operation shall be programmable in the controller.
   d. The generator set shall operate connected to the load for the duration of the exercise period.
   e. On completion of the exercise period, the transfer switch shall operate to connect the loads to the normal source by opening the alternate source contacts, and closing the normal source contacts a predetermined time period later. The timing sequence for the contact operation shall be programmable in the controller.
   f. The transfer switch shall operate the generator set unloaded for a cooldown period, and then remove the start signal from the generator set.
   g. If the normal power fails at any time when the generator set is running, the transfer switch shall immediately connect the system loads to the generator set.
   h. If the generator set fails during the exercise period and normal source is available, the transfer switch shall automatically reconnect the system loads to the normal service.
4. Generator Set Exercise (Test) Without Load Mode. The control system shall be configurable to test the generator set without transfer switch load connected. In this mode, the transfer switch shall control the generator set in the following sequence:
   a. Transfer switch shall initiate the exercise sequence at a time indicated in the exercise timer program, or when manually initiated by the operator.
   b. The transfer switch shall issue a compatible start command to the generator set as follows:
      1) On generators rated 50kW and greater, the transfer switch shall cause the generator set to start and run at idle until it has reached normal operating temperature. When the generator set has reached normal operating temperature or after an adjustable time period (whichever is shorter), the control system shall accelerate the generator set to rated voltage and frequency.
      2) On generators rated less than 50kW, the generator set shall immediately start and accelerate to rated voltage and frequency.
   c. When the control systems senses the generator set at rated voltage and frequency, it shall operate the generator set unloaded for the duration of the exercise period.
   d. At the completion of the exercise period, the transfer switch shall remove the start signal from the generator set. If the normal power fails at any time when the generator set is

running, the transfer switch shall immediately connect the system loads to the generator set.

PART 3 - EXECUTION

3.1 POWER COMPANY APPROVAL

A. The transfer switch shall be designed to meet all applicable power company requirements for connection to the power company's system, and if applicable, shall be on the power company's approved list of automatic transfer switches. Contractor shall ensure that transfer switch is specifically approved by power company for connection to their system prior to purchasing the transfer switch.

3.2 FACTORY TESTING

A. The transfer switch manufacturer shall perform a complete operational test on the transfer switch prior to shipping from the factory. A certified test report shall be submitted. Test process shall include calibration of voltage sensors.

3.3 SERVICE AND SUPPORT

A. The manufacturer of the transfer switch shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.

B. The transfer switch shall be serviced by a local service organization that is trained and factory certified in both generator set and transfer switch service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.

C. The manufacturer shall maintain model and serial number records of each transfer switch provided for at least 20 years.

D. After generator set installation, the generator set supplier shall conduct a complete operation, basic maintenance, and emergency service seminar for up to 5 persons employed by the facility owner. The seminar shall include instruction on operation of the transfer equipment, normal testing and exercise, adjustments to the control system, use of the PC based service and maintenance tools provided under this contract, and emergency operation procedures. The class duration shall be at least 4 hours in length, and include practical operation with the installed equipment.

3.4 WARRANTY

A. The automatic transfer equipment shall be warranted (by the generator supplier when a generator is supplied within the project) for a period of not less than 2 years from the date of commissioning against defects in materials and workmanship.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

END OF SECTION 26 36 23

SECTION 26 36 33

GENERATOR LOAD BANK DOCKING STATION

PART 1 - GENERAL

1.1 SCOPE

A. Provide complete factory assembled Dual purpose, dual-breaker docking station with connectors for portable generator source and load bank testing.

1.2 CODES AND STANDARDS

A. The automatic transfer switch installation and application shall conform to the requirements of the following codes and standards:
   1. NEC 700.3 (F)
   2. IBC Seismic certification as applicable for the installed location

1.3 ACCEPTABLE MANUFACTURERS

A. Trystar

B. ESL Power Systems

C. PSI Control Solutions

1.4 SUBMITTALS

A. Contractor shall submit manufacturer's drawings and data of the proposed equipment for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings and wiring diagrams, UL listing information including UL file or control number, short circuit rating or withstand rating, component data, mounting provisions, conduit entry locations and installation instructions.

B. Upon installation of equipment, Contractor shall submit manufacturer's Operating & Maintenance Manual which shall include as a minimum:
   1. Certified as-built General Arrangement drawings and Wiring Diagram.
   2. Materials / Component List including part numbers.
   3. Maintenance and service requirements.

1.5 COORDINATION

A. Contractor shall coordinate layout and installation of equipment and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels. Verify available space with generator supplier prior to ordering.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Generator Load Bank Docking Station shall be Trystar #DBDS-5 or equivalent, rated as indicated on plans.

B. Equipment shall consist of (2) kirk-key-interlocked molded case circuit breakers, male cam-style inlet connectors, female cam-style outlet connectors, power distribution blocks and grounding terminals, all housed within a padlockable enclosure. Switch shall allow source selection of permanent generator source or temporary portable source connected through camlok connectors to provide backup/emergency power to associated building. Switch shall allow connection of portable load bank connected through camlok connectors.

C. Switch shall include two circuit breakers. One molded case circuit breaker shall control the connection between the permanent generator and the automatic transfer switch. The second circuit breaker shall control the connection between the portable generator (via male cam-style connectors) and the building automatic transfer switch. All molded case circuit breakers shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless all breakers are in the "OFF" position. All molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the "ON" position. The molded case circuit breakers shall be kirk-key-interlocked to ensure that only one of these breakers can be closed at any given time

D. Enclosure
   1. NEMA 3R Rain-Tight Aluminum Enclosure unless indicated otherwise on drawings
   2. Pad-lockable front door shall include a hinged access plate at the bottom for entry of temporary cabling that prevents unauthorized tampering while in use.
   3. NEMA 3R Integrity shall be maintained while temporary cabling is connected during use
   4. Front and Side shall be accessible for maintenance
   5. Top, Side, and Bottom shall be accessible for permanent cabling
   6. Powder coat
   7. Paint after fabrication shall be Hammer tone Gray

E. Phase, Neutral, and Ground Busbar
   1. Material: Silver-plated Copper
   2. Equipment Ground Bus: bonded to box.
   3. Isolated Ground Bus: insulated from box.
   4. Ground Bus.
   5. Neutral Bus: Neutral bus rated 100 percent of phase bus.

F. Temporary generator and Load Bank connectors shall be Camlok style mounted on gland plate.
   1. Camlok connectors shall be provided for the full ampacity for all phases, neutral and ground.
   2. Camlok shall be 16 Series model and color coded according to system voltage requirements.
   3. Camlok connections shall be Bus Bar Style. Cabling or Double Set Screw is not acceptable
   4. Camlok connection shall be protected against accidental contact while not in use

G. Permanent Connection shall be factory installed broad range set-screw mechanical type, located behind a physical barrier

H. Short Circuit & Withstand Rating

1. Shall be the greater of 65 KAIC or the available fault current of the associated generator unless otherwise indicated on drawings

I. Voltage & Amperage
   1. Shall be as indicated on drawings. If not indicated, voltage shall match generator output voltage and amperage shall match or exceed generator main line circuit breaker amperage.

J. Factory Installed Phase Rotation Monitor Device:
   1. Phase monitoring relay to be Siemens 3U4512-1AR20 or equal and factory installed

K. The following additional accessories shall be included and indicated in submittal drawing as follows:
   1. Three Wire Auto Start
   2. Kirk Key Door Interlock
   3. An auxiliary contact shall be provided in the circuit breaker controlling the connection from the Permanent Generator to the building ATS and shall be factory wired to terminal blocks within the enclosure.
   4. Enclosure anti-condensation strip heater & thermostat (1.5 kW, 120 volt max)
   5. Integral duplex 20 amp, 125 volt GFCI receptacle for portable generator battery charger
   6. Integral 30 amp, 125 volt NEMA L5-30R receptacle for portable generator block heater
   7. Surge protection device
   8. Utility Light/Alarm

PART 3 - EXECUTION

3.1 INSTALLATION

A. Prior to installation of equipment, Contractor shall examine the areas and conditions under which the equipment is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.

B. Equipment shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".

C. Free standing, base mounted equipment shall be mounted on 6" concrete housekeeping pad.

D. Conduit entry into the equipment shall be by Contractor; Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the equipment. The incoming hub size shall match the conduit size for feeders and ground as shown on the drawings. The outgoing hub size shall match the conduit size for loads and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the enclosure.

E. Contractor shall terminate feeder conductors, load conductors and ground per the manufacturer's instructions. All field wiring terminations shall be torqued as required per the instructions on the equipment's power distribution blocks, circuit breakers & ground lugs.

3.2 TESTING

A. Contractor shall test equipment in accordance with manufacturer's instructions as follows:

1. With the equipment deadfront in place and the main access door closed and properly latched, actuate all Breakers/Operator Mechanisms; verify:
2. With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the “ON” position, the breaker controlling the connection between the portable generator and the automatic transfer switch cannot be turned “ON”
3. With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the “OFF” position, the breaker controlling the connection between the portable generator and the automatic transfer switch can be turned “ON” and “OFF”
4. With the breaker controlling the connection between the portable generator and the automatic transfer switch (ATS) in the “ON” position, the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) cannot be turned “ON”.
5. Confirm operation of the Docking Station’s ground receptacle by attaching a plug to the equipment’s ground receptacle and then verify that the plug is grounded to the facility ground.
6. Once normal power has been applied, confirm operation of the equipment’s integral transfer switch by following directions on main access door.

3.3 WARRANTY

A. The equipment shall be warranted by the manufacturer for a period of not less than 2 years from the date of commissioning against defects in materials and workmanship.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

END OF SECTION 26 36 33

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install all materials and labor required to provide a complete and functional Lightning Protection and Common Grounding System as indicated, in strict accordance with this section of the Specifications and the applicable Contract Drawings.

1.2 STANDARDS & QUALITY ASSURANCE

A. The lightning protection system shall comply with all requirements of the latest edition of each of the following codes and standards. The latest edition of these codes and standards form a part of this specification:
   1. U.L. Standard 96A.
   2. Lightning Protection Institute - Installation Code LPI-175.
   3. N.F.P.A. 780.

B. Equipment manufacturer shall be certified by the Lightning Protection Institute, and products approved for UL listing. All materials shall be manufactured by one of the following manufacturers:
   1. Bonded Lightning Protection Systems
   2. East Coast Lightning Protection
   3. Erico/Eritech Lightning Protection
   4. Harger Lightning Protection
   5. Preferred Lightning Protection
   6. Robbins Lightning
   7. Thompson Lightning Protection

C. For approval of LPI manufacturer other than specified, complete proposed material data and installation drawings shall be submitted to Engineer for review not less than 10 days prior to bid date.

D. In order to insure integrity of installation, the system shall be installed under the direct jobsite supervision of a Certified Master Installer/Designer, who has qualified under the LPI's Certification Program as a Master Installer/Designer.

1.3 SUBMITTALS

A. Complete shop drawings of the entire lightning protection system showing the type, size, mounting details, and location of all equipment, grounds, cable routings, roof materials (for coordination of lightning protection system materials), etc., shall be submitted to the Architect-Engineer for approval prior to start of work.

B. Submittals shall document the local manufacturer’s representative’s Certified Master Installer/Designer qualifications from LPI.

PART 2 - PRODUCTS

2.1 SYSTEM

A. System materials in general shall be copper, copper alloy or aluminum with high-copper content bronze castings or aluminum castings (all compatible with associated surface materials and installed per UL, NFPA & LPI standards), and shall comply in weight, size and composition for the class of structure to be protected. The system shall consist of all necessary cables, air terminals, mounting bases, fittings, couplings, connectors, fasteners, surge protection devices, etc., as required to give a complete and coordinated system.

B. Copper conductors shall be utilized for all downleads and below-grade conductors.

C. Aluminum components shall be utilized in cases where copper is not compatible with mounting surfaces.

D. All ground rods shall be copper-clad steel.

E. All cable and all air terminals shall bear proper UL labels.

F. Air terminals shall have blunt tips.

G. System design shall be concealed wherever practical, with roof perimeter cables concealed in parapet walls, and mid-roof cables installed under roof slabs. Exposed cable on parapet walls will only be accepted if structural details preclude cable concealment. Cable drops for roof penetrations at downlead locations shall be made with solid-bar thru-roof connectors, with copper rod flashings. Bond rebars top and bottom at each downlead position and risers. Primary and secondary bonding of roof metals and equipment shall also be under roof slabs. Ground level, intermediate and roof level potential equalization shall be provided per current building Code classifications.

H. All system fittings except cable holders, regardless of Structure classification, shall be heavy-duty type made from bronze or aluminum castings and secured with bolted-pressure clamps. Pressure plates made from stamped or pressed metal parts, or fittings utilizing crimp-type pressure devices will not be allowed. All bolts, screws, and related type hardware shall be stainless steel.

I. Contractor shall coordinate with the roofing contractor to insure compatibility of any adhesive with the roofing system in use.

J. Cable fasteners shall be substantial in construction, electrolytically compatible with the conductor and mounting surface, and shall be spaced according to LPI, UL, and NFPA code requirements.

K. Where applicable, an approved bimetal transition fitting shall be used at the roof level to change from aluminum roof conductor to copper downlead cable.

L. Surge protection devices shall be provided on the power, telecommunications and other conductive electrical services at the points of entrance into the building(s) as required by UL96A in order to obtain the UL Master Label Certificate of Inspection. It shall be the responsibility of the electrical contractor to install or verify that a proper surge protection device has been installed on the each of the building electrical services to meet this requirement. This may require surge protection devices in addition to

those specifically shown on plans or called out within other specifications.

PART 3 - EXECUTION

3.1 SUPERVISION AND CERTIFICATION

A. The manufacturer's local representative shall be a Certified Master Installer/Designer under the LPI program, and shall provide direct jobsite technical supervision to Contractor's personnel during installation to insure compliance with all Code requirements. Upon job completion, Contractors shall furnish Owners with written certification on UL Master Label "C",that system is installed in compliance with above Standards.

END OF SECTION 26 41 00

SECTION 26 43 00

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (<1000 V) power distribution and control equipment.

B. The specified unit(s) shall provide effective high energy transient voltage surge suppression, surge current diversion and high frequency noise attenuation in all electrical modes for equipment connected downstream from the facility's meter or load side of the main overcurrent device. The unit(s) shall be connected in parallel with the facility's wiring system.

C. The unit(s) shall be designed and manufactured in North America by a qualified manufacturer of suppression filter system equipment. The qualified manufacturer shall have been engaged in the commercial design and manufacturer of such products for minimum of ten (10) years.

D. All products that are submitted according to these specification will be required to meet this specification in it's entirety for both service and distribution TVSS systems. Any product that is submitted and does not comply with all parts of this specification will be subject to rejection.

1.3 DEFINITIONS

A. VPR: Voltage Protection Rating.

B. SPD: Surge Protective Device(s)

C. $I_{(n)}$: Nominal Discharge Current

1.4 SUBMITTALS

A. See specification section 26 05 00.

B. Product Data: For each type of product indicated. Include:
1. Maximum Single Impulse Surge Current Rating.
2. Surge Life (Repetitive Surge) Rating.
3. UL1449 (Latest Edition) Voltage Protection Ratings (VPR).
4. UL1449 (Latest Edition) Nominal Discharge Current (In).
5. Product dimensions and weights.
6. Furnished specialties and accessories.

C. Qualification Data:

D. Safety Agency File Number.

E. ISO 9001-2008 Certification.

F. ISO 1401-2001 Certification.

G. Operation and Maintenance Data: For SPDs to include all submittal data and any applicable operation and maintenance manuals.

H. Warranties: Sample of special warranties.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.

B. The unit shall be UL 1449 Listed and CUL Approved as a Surge Protective Device and UL 1283 Listed as an Electromagnetic Interference Filter

C. Provide 2nd party certified data demonstrating SPD response to ANSI/IEEE C62.41.2-2002 standard waveforms when tested according to IEEE C62.45.

D. Comply with NFPA 70.

E. All SPDs provided within this project at the service entrance, distribution panels, and sub-panels shall be from the same manufacturer.

1.6 PROJECT CONDITIONS

A. Service Conditions: Rate SPDs for continuous operation under the following conditions unless otherwise indicated:
1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 30 to 150 deg F.
3. Humidity: 0 to 95 percent, non-condensing.
4. Altitude: Less than 13,000 feet above sea level.

1.7 COORDINATION

A. Where field-mounted SPD's are specifically shown on plans, coordinate locations of field-mounted SPDs to allow adequate clearances for maintenance.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.
1. Warranty Period: 10 years from date of Substantial Completion.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Replaceable Protection Modules: 1 of each size and type installed, where field-replaceable modular SPDs are provided.
   2. Fuses: 1 of each size and type installed, where field-replaceable fuses are provided.

PART 2 - PRODUCTS

2.1 SURGE PROTECTIVE DEVICES

A. Manufacturer:
   1. Integral Devices: Surge Protective Devices shall be as manufactured by the distribution equipment manufacturer (Square D, etc.), or by Surge Suppression Inc. if all of the performance of this specification are met and all UL listing of the equipment manufacturer are met.
   2. External Devices (where specifically specified on plans): Surge Protective Devices shall be as manufactured by the distribution equipment manufacturer (Square D, etc.) or Surge Suppression Inc.

B. Each Surge Protective Device shall:
   1. Be internal to the associated distribution equipment (without violating any applicable UL listings) unless specifically shown otherwise on plans.
   2. Be UL 1449 (Latest Edition) listed.
   3. Have short-circuit current rating complying with UL 1449 (Latest Edition), that matches or exceeds the short-circuit rating of the associated distribution equipment.
   4. Be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.
   5. Have fuses, rated at 200-kA interrupting capacity.
   6. Have a minimum UL 1449 Nominal Discharge Current (I_n) Rating of 20kA.
   7. Be fabricated using bolted compression lugs.
   8. Provide suppression for all ten (10) modes of protection.
   9. Have LED indicator lights for power and protection status of each phase.
   10. Have audible alarm, with silencing switch, to indicate when protection has failed.
   11. Have form-C contacts rated at 2 A and 24-V ac minimum, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with facility monitoring and control system if monitoring by that system is required by plans or other specifications.
   12. Have six-digit transient-event counter, mounted to front of equipment door, set to totalize transient surges (externally mounted SPD's may have the transient –event counter monted on the visible face of the SPD).
   13. Meet all UL 96A requirements (for Lightning Protection Systems) where the device is installed at a service entrance of the facility. At a minimum, these devices shall:
      a. Be marked as Type 1 or Type 2 SPDs with product Identity consisting of "Surge Protective Device" or "SPD", and identifying all ratings so required by UL96A and the 4 digit alpha numeric Control Number.
      b. Have a minimum UL 1449 Nominal Discharge Current (I_n) Rating of 20kA.
      c. Be UL listed and labeled with holographic label.

C. Peak Single-Impulse Surge Current Rating shall be meet the following minimums unless specifically shown otherwise on plans:

Application	**Per Phase**	**Per Mode**
Service Entrance Devices	240 kA	120 kA
Downstream Devices	160 kA	80 kA

D. The ANSI/UL 1449 voltage protection rating (VPR) in grounded wye circuits, the SPDs shall not exceed the following:

Modes	**208Y/120V**	**480Y/277V**	**600Y/347V**
L-N,L-G, N-G	800	1200	1500
L-L	1200	2000	2500

E. The ANSI /UL 1449 VPR for 240/120 V, 3-wire or 4-wire circuits with high leg shall not exceed the following:

Modes	**240/120V**
L-N,L-G, N-G	1200/800

2.2 ENCLOSURES

A. Where external units are specifically specified on plans, units not mounted within electrical distribution equipment (such as switchboards, MCC's, etc.) shall be provided in enclosures with NEMA enclosure ratings that match or exceed the NEMA enclosure ratings of the equipment from which the units are fed. For example, a unit fed from a NEMA 4X stainless steel panelboard shall also be mounted within a NEMA 4X stainless steel enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All SPD's shall be integrally-mounted within the associated distribution equipment unless specifically shown otherwise on plans.

B. Install SPDs at service entrance on load side, with ground lead bonded to service entrance ground.

C. Install SPDs downstream of the service entrance with conductors or buses between suppressor and points of attachment as short and straight as possible. The lead lengths between the TVSS unit and the equipment being protected shall not exceed fourteen (14) inches without approval from the engineer. Do not bond neutral and ground. Leads shall be as straight as possible with no sharp bends.

D. Where externally-mounted SPD's are specifically shown on plans, provide circuit breaker as directed by

the SPD supplier as a dedicated disconnecting means for SPD unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

A. Ensure that interiors are free of foreign materials and dirt.

B. Check and test switches, pushbuttons, meters for proper operation.

C. Check and test indicating lights for proper operation and color.

D. Perform manufacturer's on site field test procedures.

3.3 STARTUP SERVICE

A. Do not perform insulation resistance (MEGGER) tests of the distribution wiring equipment with the SPDs installed. Disconnect all wires, including neutral, before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 SYSTEM WARRANTY

A. The SPD system manufacturer shall warranty the entire SPD system against defective materials and workmanship for a period of ten (10) years from the date of substantial completion. This warranty is in effect as long as the unit is installed in compliance with the manufacturer's installation, operation, and maintenance manual, UL Listing requirements, and any applicable national or local electrical codes.

B. Any SPD device which shows evidence of failure or incorrect operation, including damage as the result of lightning strikes, during the warranty period shall be replaced by the manufacturer at no charge to the owner. Warranty will provide for multiple exchanges of any inoperable devices at any time during the warranty period which starts at the date of substantial completion of the system to which the surge suppressor is installed.

C. The manufacturer is required to have a nationwide network of factory-authorized local service representatives for repair and service of this product. The manufacturer shall have a dedicated 1-800 telephone number for service problems and questions. This number shall be manned by a knowledgeable factory employee to ensure prompt response to any emergency situation that may arise.

END OF SECTION 26 43 00

SECTION 26 50 00

LIGHTING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Lighting Fixtures

B. Drivers

1.2 SUBMITTALS

A. Complete submittals shall be provided identifying all lighting fixture types and options, all lamp types (where applicable) and compliance with all contract requirements. The absence of clear submittal information specifically listing exceptions/deviations from detailed contract requirements will be understood to indicated that the contractor/supplier intends to meet all contract requirements. Refer to specification section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Lighting fixtures shall be furnished as shown on plans and specified herein. It shall specifically be the responsibility of Contractor to verify exact types ceilings, walls, etc. and recessing depth of all recessed fixtures and furnish the specific mounting trims and accessories of the specified and/or accepted fixture specifically for the ceiling, wall etc. in which each fixture is to be installed.

B. Base bid manufacturers are listed on the lighting fixture schedule. Manufacturers listed without accompanying catalog numbers are responsible for meeting the quality standards, efficiency, maximum wattages and photometric distributions set by the specified product.

C. All lighting fixtures shall be so designed and shall have drivers and other similar items so installed as to function without interruptions or failures when operating in the environment in which they are proposed to be installed. Special attention shall be given to environments with potentially high ambient temperatures such as attic spaces, exterior soffits, confined interior soffits, coves, unconditioned spaces, etc. and shall be addressed by providing fixtures with suitable high ambient temperature ratings, remote mounting of drivers/ballasts, providing approved ventilation, etc. as directed by fixture manufacturer and approved by engineer, at contractor's expense.

D. All fixtures installed such as to create penetrations through fire rated ceiling or wall assemblies shall be labeled as suitable for that purpose or installed with covers, tenting or other means as required to maintain the fire rating of the assembly.

2.2 LED LUMINAIRES

A. For the purpose of these specifications, LED Luminaires shall be defined as the entire LED fixture assembly including LED array, drivers, housing, electronics, etc. that compose the lighting fixture.

B. Furnish and install LED Luminaire of proper size, type, efficacy, delivered lumen output, color temperature, distribution pattern, operational life, and CRI as shown on drawings.

C. LED Luminaires shall be tested in accordance with LM-79 and LM-80 standards.

D. LED drivers shall comply with NEMA 410 standards for inrush current, etc.

E. Exterior, pole mounted LED Luminaires shall be provided with an easily-serviceable, UL recognized surge protection device that meets a minimum 10kA Category C Low operation (IECC C62.41.2-2002). Device shall be wired in front of light engine(s) and driver(s) and shall fail "open" such as to prevent fixture operation after a surge protection failure.

F. LED Luminaires shall have a guarantee-warranty of at least five years unless specifically noted otherwise on contract documents.

G. LED Luminaire assembly shall comply with ambient temperature requirements specified in General section above.

2.3 STEMS/PENDANTS

A. Hangers shall be approved ball aligner type swivel, 30 degrees from vertical with swivel below canopy.

B. Stems/Pendants shall be rigid or IMC conduit unless specified otherwise on plans. Proposed stem/pendant types shall be submitted for review prior to shipment of light fixtures from factory.

C. Stems/Pendants shall be provided as required to prevent swaying of fixtures due to HVAC system airflow or other similar occurrences.

D. Shall be painted the same color as the fixture trim unless noted otherwise.

2.4 MANUFACTURER

A. Fixtures and stems shall be manufactured as shown in fixture schedule or approved equals.

B. Drivers shall be as manufactured by Philips/Advance, GE, Lutron, Magnatec, Motorola, EldoLED or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION OF LIGHTING FIXTURES

A. Support:
1. Support of all lighting fixtures shall be responsibility of electrical contractor. All lighting fixture supports shall be installed in accordance with lighting fixture supplier's recommendations.
2. Contractor shall coordinate installation requirements for all wall-mounted fixtures (especially for wall-mounted fixtures on uneven wall surfaces, etc.) as required to assure a level/flat mounting surface and level/plumb/secure finished installation. Contractor shall provide flat mounting plates or other mounting provisions where necessary. Any proposed mounting plates, etc. shall be submitted to and approved by project architect prior to ordering materials.

3. Fixtures shall be supported independent of ceiling from structural members of building.
4. Lay-in fixtures shall be supported by four (4) taut 12 gauge hanger wires connected from each corner of the fixture to the structure above so that fixture is supported independent of the ceiling.
5. Other recessed light fixtures (including recessed downlights) shall be supported with two (2) taut 12 gauge hanger wires connected from opposing corners of the light fixture to the structure above so that fixture is supported independent of the ceiling.
6. Pendant mounted fixtures shall be directly supported from the structure above using a 9 gauge hanger wire or an approved alternate support without using the ceiling suspension system for direct support.
7. Tandem fixtures may utilize common hanger wires.
8. All lay-in fixtures shall be attached to ceiling grid by means of approved clips and in accordance with the N.E.C.
9. Contractor shall submit typical hanging detail to Engineer before installing any fixtures.

B. Connections:
1. All grid fixtures shall be wired by flex individually to junction and not wired fixture to fixture.
2. All flex shall contain 3 conductors (3rd wire ground). Ground wire shall be securely grounded at each end. Other conductors shall be connected by approved connectors.

C. Row-Mounted fixtures:
1. All stems on row-mounted fluorescent fixtures shall be installed as follows (except fixtures with slide grip hangers):
   a. One stem shall be installed in the first fixture knockout from end of row (on the first and last fixture of the row).
   b. One stem shall be installed between each two fixtures. Stem shall center joint where fixtures join and shall attach by use of “joining plates”.
2. All fixtures in continuous rows other than recessed grid type shall be connected by nipples with locknuts bushings.

D. Coordination:
1. Contractor shall coordinate all dimensions & locations of light fixtures prior to rough-in to insure proper fit and coordination with other trades.
2. Contractor shall verify exact ceiling types being installed and shall adjust fixture trim types accordingly (prior to submitting light fixture shop drawings).

END OF SECTION 26 50 00

SECTION 27 05 00

AUXILIARY SYSTEM CABLES, 0-50V

PART 1 - GENERAL

1.1 DESCRIPTION

A. Cables rated for 0V-50V application

PART 2 - PRODUCTS

2.1 GENERAL

A. Unless specified otherwise, all cables within the scope of this specification section shall:
1. Be rated for exposed cable tray installation.
2. Be plenum rated.
3. Be UL-rated for the proposed application.
4. Be multi-conductor with overall outer sheath as required by the application. The insulation of each conductor within the overall multi-conductor cable shall be uniquely color-coded. Ground conductors (when provided) within the multi-conductor cable shall have green insulation. Conductors with green insulation shall not be used for conductors other than ground.
5. Utilize copper conductors.
6. Have wire gauge as required to limit voltage drop to acceptable limits determined by the system supplier and to meet all applicable code requirements.
7. Where installed underground, within slab-on-grade or in exterior locations, be rated for wet locations.
8. Where required for specific systems, meet the specific requirements (conductor quantity, wire gauge, insulation type, shielding, etc.) of the system supplier.

2.2 CLASS 1 CONTROL CABLING (120VAC CONTROL CIRCUITS, ETC.)

A. In addition to above requirements, and unless specified otherwise, Class 1 control cabling shall:
1. Be rated for 600V.
2. Be industrial grade.
3. Have stranded conductors.
4. Have sunlight/oil-resistant PVC/Nylon insulation and jacket with ripcord.
5. Be manufactured by Belden, AlphaWire or General Cable.

2.3 CLASS 2 & 3 CONTROL CABLING (FED FROM CLASS 2 OR 3 POWER SUPPLIES)

A. In addition to above requirements, and unless specified otherwise, Class 2 & 3 control cabling shall:
1. Be rated for 300V.
2. Be shielded if so recommended by the system supplier/integrator.
3. Have twisted conductors.
4. Have plenum-rated insulation/jacket with ripcord.
5. Be manufactured by AlphaWire, Belden, General Cable, Superior Essex or West Penn.

2.4 NETWORK CABLING

A. Furnish and install all Ethernet, Fiber Optic and Backbone Copper Telephone cabling in accordance with all BICSI requirements and in accordance with other applicable specification sections.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Routing:
1. All wires and cables shall be installed in conduit unless specifically noted otherwise. Where conduit is not otherwise required by contract documents, 0-50V Cabling located within concealed, accessible ceiling spaces (such as above lay-in ceilings) may be run without conduit if the following requirements are met:
   a. Cabling is plenum-rated, multi-conductor.
   b. Cabling is supported by cable tray or with J-hook supports on intervals not to exceed 5'-0" on center. Cabling shall be supported solely from the cable tray or j-hooks supported from the building structure, without using piping, ductwork, conduit or other items as supports.
   c. Cabling is neatly formed, bundled and tied with plenum-rated Velcro straps on intervals not to exceed 30" on center.
   d. Properly-sized conduit(s) are provided wherever cabling enters an inaccessible or exposed area (such as above gyp board ceilings, within walls or through walls).
   e. Cabling is not a part of a Fire Alarm System, Smoke Control System, Emergency Generator Control System or other life-safety related system.
2. End bushings shall be provided on both ends of all raceway terminations.
3. No splices shall be pulled into conduit.
4. No cabling shall be pulled until conduit is cleaned of all foreign matter.

B. Penetrations:
1. All fire/smoke barrier penetrations shall be made in accordance with a U.L. listed assembly.
2. For cabling not installed in conduit:
   a. Fire/smoke barrier penetrations shall be sealed utilizing an enclosed fire-rated pathway device (STI EZ Path or equal) containing a built-in fire sealing system sufficient to maintain the hourly fire rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed or retrofitted without the need to remove or reinstall firestop materials. The pathway shall be UL Classified and tested to the requirements of applicable ASTM/UL1479 standards.
3. For cabling installed within conduit from endpoint to endpoint:
   a. Fire/smoke barrier penetrations shall sealed utilizing fire caulk or other equivalent firestop systems around perimeters of conduits per UL requirements.
4. For cabling installed within cable trays:
   a. Fire/smoke barrier penetrations shall be sealed with one of the following methods:
      1) Continuous cable tray through the penetration, with a combination of large firestop pillows and small firestop pillows contained, supported and secured (to prevent unauthorized removal) on both sides by aluminum wire mesh and firestop putty. Firestop pillows shall be STI Series SSB or equal and Firestop putty shall be STI Spec Seal or equal.

2) Cable tray broken at the penetration, with fire/smoke barrier penetrations sealed utilizing an enclosed fire-rated pathway device (STI EZ Path or equal) containing a built-in fire sealing system sufficient to maintain the hourly fire rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed or retrofitted without the need to remove or reinstall firestop materials. The pathway shall be UL Classified and tested to the requirements of applicable ASTM/UL1479 standards.

C. Excess Cabling:
1. Excess cabling shall be neatly coiled within all junction boxes, pullboxes, wireways, etc. and at all terminations as required to allow future re-termination of cabling.

D. Terminations:
1. All conductors/cabling (including spare conductors) shall be properly terminated unless specifically directed otherwise. See below for general termination hardware requirements.
2. Cabling shall be neatly formed, bundled and tied at all terminations.

3.2 SPLICES/CONNECTIONS/TERMINATIONS:

A. Network Cabling:
1. Network and fiber optic cabling shall be continuous from endpoint to endpoint and shall not be spliced unless specifically noted otherwise.

B. Control Cabling:
1. Connections shall be made with T & B Sta-Kon wire joints EPT66M, complete with insulating caps. To be installed with WT161 Tool or C nest of WT11M Tool, Ideal Super - Nuts (not wire nuts), Ideal Wing Nuts, or Buchanan Elec. Products B Cap or Series 2000 Pressure connectors complete with nylon snap on insulators to be installed with C24 pressure tool.

C. Shielded cabling:
1. Unless directed otherwise by the system supplier, 0-50V cable shielding shall be grounded at the PLC/control panel end only (not at the field device end) with a termination kit as directed by the PLC/control panel supplier.
2. Shielded cabling shall be continuous from endpoint to endpoint and shall not be spliced without prior written approval from the Engineer.

3.3 LABELING

A. Refer to Specification Section 26 05 53 for all labeling requirements.

END OF SECTION 27 05 00

SECTION 28 13 00

FIRE ALARM SYSTEM

PART 1 – GENERAL

1.1 GENERAL DESCRIPTION

A. Provide all materials and labor for the engineering, design and installation of a new automatic fire detection and alarm system, hereafter referred to as the “System”, for the University of Alabama.

B. Where used throughout this specification, the term “provide” shall mean to furnish and install.

C. The work shall be subject to the terms and conditions of the University of Alabama Facilities Department.

D. All work shall be performed in accordance with these specifications and good practice. No modifications to these specifications will be accepted without the express written approval of the Owner. It is the Contractor's responsibility to document Owner's approval of any such modifications prior to the execution of work.

E. Fire Alarm systems are required for all new construction unless otherwise specified by UA.

1.2 INTENT OF SPECIFICATIONS

A. Work performed pursuant to these specifications shall be complete in every respect, resulting in a system installed entirely in accordance with the specifications, applicable codes, standards, manufacturer's recommendations and Underwriters Laboratories Inc. (UL) listings.

B. It is further intended that upon completion of this work, the Owner be provided with:

1. Complete information and drawings describing and depicting the entire system as installed, including all information necessary for maintaining, troubleshooting, and/or expanding the system at a future date.
2. Complete documentation of system testing.
3. Certification that the entire system has been inspected and tested, is installed entirely in accordance with the applicable codes, standards, manufacturer's recommendations and UL listings, and is in proper working order. Contractor shall complete the "Fire Alarm System Certification and Description" as required by NFPA 72.
4. A copy of the final software program in each of written form, electronic media appropriate for technician downloading onto the system, and permanent electronic disk format.
5. All necessary owner-operator passwords.

6. All points of contact at the manufacturer and all site specific system information necessary to permit the complete access to and modification of the system programming by qualified technicians.
7. Provide executed "Release of Lien" forms from Contractor and each subcontractor.
8. A guarantee letter indicating the date of commencement and duration of the system guarantee and of the service and maintenance agreement.

C. All equipment, devices, appliances, conductors, raceway and other materials shall be new.

1.3 WORK INCLUDED

A. Provide and install a new UL Listed, addressable fire alarm system as described herein and as shown on the plans. The system shall be wired, connected, and left in first class operating condition. All wiring, including low voltage fire alarm system conductors and other cabling related to the fire alarm system such as fiber optic communications, mass communication and fire alarm network shall be installed in conduit. The Contractor is to provide all devices, appliances, equipment, conduit, wiring and labor necessary to provide a completely operational fire alarm system consisting of but not limited to:

1. Fire alarm control unit(s) with an integral supervised RS-232 C output.
2. Manual fire alarm boxes at all at grade level exit doors unless otherwise specified by UA.
3. Addressable, spot type, photoelectric smoke detectors in rooms containing fire alarm panels, electrical and telephone closets, mechanical rooms, and other areas as required by local codes.
4. Complete area smoke detection or corridor smoke detection as warranted by the hazard to occupants in non-sprinklered buildings.
5. Corridor smoke detection in dormitories and other residential buildings with enclosed, interior corridors (sprinklered and non-sprinklered).
6. Duct type smoke detectors in supply and return air systems having a capacity greater than 2,000 CFM.
7. Duct type smoke detectors in supply air and exhaust air plenums of air conditioning systems having a capacity greater than 15,000 CFM, and at each connection to a vertical duct or riser serving two or more stories. Each duct detector shall have a remote test switch that will be accessible (within 8' AFF) to Maintenance Department.
8. Heat detectors in elevator machine room and/or hoistway within 2 feet of each sprinkler for elevator shutdown where provided.
9. Additional automatic heat or smoke detection as required for non-sprinklered buildings or based on an assessment of building/area hazards.
10. Conventional (non-addressable) smoke and/or heat detection devices in spaces where the environment is unfavorable for addressable devices. Such conventional devices shall be provided in a zoned configuration which aids in the annunciation of the location installed. Annunciation on the addressable fire alarm system shall be via addressable monitor modules located in a conditioned space.

11. Audible notification appliances shall be installed, spaced and tapped (when speakers are mandated by code) so as to produce a sound output on alarm that is clearly audible above the ambient noise level throughout the building. In no case shall the audible alarm be less than 15 dBA above the ambient room noise level or less than 5 dBA above the maximum ambient noise level in public and common areas. In no case should the fire alarm system produce sound in excess of 110 dBA.
12. Visible notification appliances in all public or general areas including but not limited to, public restrooms, meeting rooms, dining rooms, classrooms, copy rooms, conference rooms, assembly areas, common laboratories, common areas, corridors, and offices.
13. Firefighters' telephone jacks and associated wiring in exit stairways, exit enclosures, fire pump room, emergency generator room, and elevator cabs and lobbies where required.
14. Interface wiring to fan(s) and air handling unit(s) for start-up or shut down of fans when smoke is detected and/or smoke control mode operation (where provided) is initiated.
15. Devices, equipment, and wiring as necessary to monitor the activation of new or existing sprinkler and standpipe system alarm and supervisory devices.
16. Devices, equipment, and wiring as necessary to monitor special fire or gas detection systems where provided in laboratory spaces.
17. Devices, equipment, and wiring necessary to operate and control magnetic door holders, unlocking mechanisms, and automatic door assemblies associated with access-controlled rooms, smoke control systems (where provided), and etc.
18. Relays necessary to initiate primary and alternate floor elevator recall and shunt trip (when sprinklers are provided in hoistways and machine rooms) on all existing elevators. All interfaces to elevator controllers shall be provided by a qualified elevator contractor that shall be a subcontractor to the fire alarm contractor to conduct this work.
19. Devices, equipment and wiring necessary to monitor the fire pump controllers in accordance with NFPA 20 where provided.
20. Devices, equipment, and wiring to monitor emergency generator in compliance with NFPA 110 where provided.
21. Provide and install devices, equipment, and wiring necessary to monitor the activation of new or existing special hazard fire suppression systems including but not limited to kitchen hood suppression systems and clean agent suppression systems where provided. Final checkout of inter-connections shall be made by activating the special hazard fire suppression systems(s) detection circuits. Contractor shall include the services of the special hazard fire suppression systems(s) contractors(s), if needed, to test fully the interconnections.
22. UL Listed electrical surge protection for all control equipment including primary power supplies.
23. Transient voltage surge suppression for all fire alarm system circuits upon entry and exit from each building.

B. Fire Command Centers shall include the equipment identified in Section 911 of the International Fire Code and as further required by this Specification.

C. Provide protection of smoke detectors during installation.

D. Test and adjust all new equipment and systems.

E. Prepare and submit shop drawings, contractor record drawings and other submittals required herein.

F. Guarantee all new equipment and systems for one year after final acceptance of the system by the Owner.

G. Obtain, secure, and pay for all permits, plan check approvals, and inspections necessary to perform the work.

H. Repair all damage to building finishes resulting from this work in accordance with the requirements of the University of Alabama.

I. Coordinate all work with other Contractors working in the building or concurrent construction/remodeling or installation of other systems (e.g. adjusting waterflow alarm switch retards by the Sprinkler Contractor).

J. Remove all existing fire alarm system components and all accessible conduits, conductors, backboxes, etc.

K. All devices installed outdoors or within areas exposed to weather or wet locations shall be installed as NEMA 3R enclosures. All devices installed in areas subject to directed water streams or potentially corrosive atmospheres shall be provided with NEMA 4 or 4X enclosures or as required. Electrical raceway and fittings shall be as required for connection to the NEMA 3R, 4, or 4X enclosures.

1.4 OWNER'S REPRESENTATIVE

A. All contacts with the new fire alarm project for the University of Alabama shall be directed to the Owner's Representative, hereafter referred to as the Owner:

Ms. Mary Katherine Holt, Project Manager
University of Alabama
Construction Administration
1205 14th Street
Tuscaloosa, Alabama 35401
Phone: (205) 348-26638
Fax: (205)348-9105
Email: zickl001@ua.edu

B. The Owner will issue all approvals and instructions required for this work. No other person may issue an approval or instructions to the Contractor without the written permission of the Owner. Acceptance of unauthorized or oral approvals or instructions by the Contractor shall be entirely at the Contractor's risk and in no case shall such

unauthorized or oral approvals or instructions constitute an oral contract or otherwise be binding upon the Owner.

1.5 WORKING CONDITIONS

A. It shall be the Contractor's responsibility to inspect the job site and become familiar with the conditions under which the work will be performed. Inspection of the building may be made by appointment with the Owner. Contractors are requested to inspect the building prior to the pre-bid meeting.

B. A pre-bid meeting will be held on site to familiarize the Contractors with the project. Failure to attend the pre-bid meeting may be considered cause for rejection of the Contractor's bid.

C. Fire alarm system engineering drawings, including the location of devices and appliances, will be provided. It shall be the Contractor's responsibility to review the layout for the purpose of preparing his bid.

D. The Contractor will be responsible for attending a pre-construction meeting and weekly construction coordination meetings with the Owner, and preparing minutes of these meetings. Construction coordination meetings will be scheduled by the Owner. The frequency of required meetings may be decreased, at the Owner's option, if warranted by the progress of the project.

E. All work may be conducted during acceptable working hours, to be identified by the project manager, by properly coordinating the work with the Owner. Noise restrictions do apply. The core drilling, testing of evacuation signals, and other work disruptive to occupants will be prohibited between 6:00 a.m. and 6:00 p.m., Monday through Friday, and will be explained at the pre-bid meeting.

F. The Contractor shall be responsible for prior coordination of all work and demolition with the Owner.

G. New fire alarm systems and devices/appliances shall be put into service as soon as they are functional. Once put into service, they shall not be removed from service without the Owner's written authorization.

H. In return for progress payments, less retention, made to the Contractor by the Owner during the course of the work, the Owner shall assume title to all new systems, equipment, and devices/appliances as they are delivered to the job site, installed and put into service.

I. Assumption of title for new systems, equipment, and devices by the Owner shall not imply acceptance of those systems, equipment, and devices by the Owner nor shall it relieve the Contractor from his obligation to meet all requirements of these Specifications.

J. The Owner reserves the right to make beneficial use of all new systems, equipment and devices/appliances, as those systems, equipment, and devices/appliances are put into service, throughout the installation period. Such beneficial use shall not imply acceptance of those systems, equipment, and devices/appliances by the Owner, nor shall it relieve the Contractor from his obligation to meet all requirements of these Specifications. Beneficial use of the system shall not cause the guarantee period to begin prior to the Owner's final acceptance as required by Section “Guarantee” herein.

1.6 QUALITY ASSURANCE

A. Codes, Standards, Ordinances, and Permits:

1. All work shall comply with the current codes adopted and enforced by the following agencies: Designer of Record, shall verify the edition of the applicable codes at the time of design and construction.

a. Alabama Building Commission

1) International Fire Code
2) International Mechanical Code
3) NFPA 70, National Electrical Code
4) ADA Accessibility Guidelines for Buildings and Facilities

b. State Fire Marshal’s Office (National Fire Protection Association (NFPA) National Fire Codes)

1) NFPA 72, National Fire Alarm Code
2) NFPA 90A, Installation of Air Conditioning and Ventilating Systems
3) NFPA 101, Life Safety Code

c. Tuscaloosa Fire and Rescue Service

1) International Fire Code and referenced standards

2. All work and products shall also conform to the following nationally recognized standards:

a. ANSI S3.41, Audible Emergency Evacuation Signal
b. UL 864, Control Units for Fire Protective Signaling Systems
c. UL 1481, Power Supplies for Fire Protective Signaling Systems
d. UL 268, Smoke Detectors for Fire Protection Signaling Systems
e. UL 464, Audible Signal Appliances, 8th Edition
f. UL 1971, Signaling Devices for the Hearing Impaired
g. UL 1480, Speakers for Fire Protective Signaling Systems

3. All work and materials shall conform to all Federal, State and local codes and regulations governing the installation, including the current editions of the

International Building and Fire Codes, and the codes, standards, guides and recommended practices included in the current NFPA National Fire Codes.

4. If there is a conflict between the referenced NFPA standards, federal, state or local codes, and this specification, it is the Contractor's responsibility to immediately bring the conflict to the attention of the Owner for resolution. Where conflict arises between the International Fire Code and NFPA 101, Life Safety Code, the most stringent code requirement will be enforced.
5. All devices, appliances, systems, equipment, and materials furnished and installed shall be new and listed by Underwriters Laboratories Inc. (UL) for their intended use. All equipment shall be installed in accordance with the manufacturer's recommendations and the UL listing limitations. Listing requirements for separate voice, fire alarm systems, smoke control system equipment and smoke detectors shall be met. The Contractor shall provide evidence with his submittal of listings for all proposed equipment and combinations of equipment.
6. All devices, appliances, systems, equipment, and materials furnished and installed shall be of types or models approved and required by NFPA Standards or UL listing for use in systems and occupancies of this type.
7. The Contractor shall be responsible for filing of all documents, paying all fees (including, but not limited to plan checking and permit) and securing all permits, inspections and approvals necessary for conducting this work. Upon receipt of approved drawings from the Authority Having Jurisdiction, the Contractor shall immediately forward two sets of drawings to the Owner. These drawings shall either be stamped approved or a copy of the letter stating approval shall be included.

B. Contractor Qualifications

1. The Contractor shall:

   a. Any contractor or subcontractor engaged in the installation, modification, configuration, programming or testing of a fire alarm system shall have a valid State Fire Alarm permit. This includes the installation or termination of fire alarm wiring, devices, panels and other equipment.
   b. Provide a job site supervisor/foreman who is to be present on site each day that work is actively in progress, as appropriate. The jobsite supervisor/foreman shall be a minimum National Institute for Certification in Engineering Technologies (NICET) Level II in Fire Alarm Systems. A daily site visit is required as a minimum. This individual shall be the same person throughout the course of the project, unless otherwise approved in writing by the Owner.
   c. System configuration, installation, programming, and testing shall be supervised by a technician who is NICET Level III or IV in Fire Alarm Systems, trained by the Contractor.
   d. Hold all licenses and permits necessary to perform this work in Tuscaloosa, Alabama.
   e. Have at least five years of experience in the installation of systems of this type and shall be familiar with all applicable local, state, and federal laws

and regulations. Provide a project list representing projects of similar scope in the past three years including references.

f. Technicians, who shall be on-site or have a level of responsibility and involvement with this project, shall be submitted for review and acceptance. A copy of their NICET Certification (minimum Level III or IV, Fire Alarm Systems) shall be submitted with the submittal documents.

g. Be regularly engaged in the design, servicing, installation, and testing of fire detection, alarm, and emergency voice/alarm communication systems.

1.7 SUBMITTALS

A. General:

1. The Owner's Consultant shall review and recommend approval/disapproval or take other appropriate action on the Contractor's submittals including shop drawings, samples, documentation, and record drawings. This review is to verify conformance to project specifications and design concepts expressed in the contract documents. This action shall be taken with all reasonable promptness as to cause no delay in the work, while allowing adequate time to permit adequate review. Review of such submittals is not conducted for the purpose of determining the accuracy and completeness of other details (i.e., dimensions) or for substantiating installation or performance of equipment or systems designed by the Contractor, all of which remain the Contractor's responsibility to the extent required by the contract documents. The Owner's Consultant's review shall not constitute approval of safety precautions of construction, means, methods, techniques, sequences of procedures, or approval of a specific assembly of which the item is a part.

2. The Contractor shall submit 100% shop drawings to the Owner, Owner’s Consultant, and all reviewing authorities. All comments received from these parties shall be incorporated into a 100% corrected final set of shop drawings. The Contractor will not be able to bill for preparation of shop drawings until all comments have been incorporated and the shop drawings have been approved by the Owner, Owner’s Consultant, and all reviewing authorities.

3. If the 100% corrected submittal is found not to conform to the requirements of these specifications and incorporate all comments, the Contractor shall be required to resubmit with modifications. The Contractor shall be responsible for the Owner's extra expenses for subsequent review(s) of rejected submittals necessitated by the Contractor's failure to make the requested modifications. Such extra fees shall be deducted from payments by the Owner to the Contractor. Approval of the submittals by the Owner shall, in no case, relieve the Contractor of his responsibility to meet the requirements of this specification.

B. Subcontractors:

1. Contractor shall submit with his bid, a list of all proposed subcontractors. All proposed subcontractors are subject to the approval of the Owner.

2. The installing electrical Subcontractor(s) shall:

    a. Hold all licenses and permits necessary to perform this work.
    b. Have at least five years of experience in the installation of systems of this type and be familiar with all applicable local, state and federal laws and regulations.
    c. Be regularly engaged in the servicing, installation and testing of fire detection, emergency voice communications, and alarm systems, as appropriate.

C. Equipment Lists:

1. The Contractor shall submit with his bid a detailed equipment list, identifying types, models and quantities of all materials, devices, and equipment proposed. This submittal shall include manufacturers' data sheets showing the types and models of all equipment, devices, material and wire proposed. Evidence of UL listings and local approvals shall be submitted with the data sheets. The submittal shall include, but not be limited to, the following:

    a. Conduit, raceway, junction boxes, terminal cabinets, device backboxes, fittings, hangers, and mounting hardware.
    b. Wire, cable, connectors, terminal strips, and electrical tape.
    c. Fire alarm control equipment and annunciators, including all components, modules, surge suppression, and enclosures.
    d. All components of voice evacuation and firefighters' communication equipment.
    e. Manual fire alarm boxes, detectors, auxiliary function relays and solenoids, and notification appliances.
    f. Power supplies and standby batteries.
    g. Any other materials, devices, or equipment to be provided.
    h. Fire alarm schematic riser diagram supplemented with narrative descriptions as necessary for clarity and completeness.

2. When a data sheet shows more than one product, the proposed product shall be clearly indicated by arrows or other suitable means.

D. Work Schedule:

1. The Contractor shall submit with his bid a proposed work schedule and representative chart (such as a Gantt chart). This schedule shall indicate the time necessary for:

    a. Project start-up.
    b. Property survey.
    c. Shop drawing submittals.
    d. Installation.
    e. Contractor testing.
    f. Final acceptance tests and commissioning.

2. The proposed work schedule will be reviewed and finalized during the pre-construction meeting and will be updated at each weekly construction coordination meeting.

E. Permits, Licenses, and Certificates:

1. Prior to start of installation, the Contractor shall obtain and submit copies of all permits, licenses, certificates and approvals necessary to conduct this work.

F. Shop Drawings:

1. Prior to installation, but within 30 days after awarding of the contract, the Contractor shall submit two full sets of plotted shop drawings, a copy of the AutoCAD files, two full sets of data sheets as required in Specification Section 1.7.C, updated to reflect any changes, and installation manuals/instructions detailing the manufacturer's installation recommendations for all equipment to be installed to the Owner for approval. Installation prior to receipt of approved shop drawings shall be at the risk of the Contractor.
2. The shop drawings shall consist of the following:

a. A drawing legend sheet identifying:

1) All symbols used on the drawings, by type of device or equipment, manufacturer, and manufacturers part number. This information shall correspond to the manufacturer's catalog data sheets required elsewhere in this section.
2) All conventions, abbreviations, and specialized terminology used on the drawings, as necessary to understand and interpret the information contained therein.
3) All color codes and conduit, conductor/circuit, and device numbering systems.
4) A complete drawing list/index identifying all drawings in the shop drawing package by title, drawing number, and Specification cross-reference.

b. Clean architectural floor plans drawn to 1/8” = 1’-0” scale on ‘D’ size sheets and a system riser diagram with a title block on each drawing. Floor plan drawings required for this submittal shall be generated using the bid drawings as background in AutoCAD Release Version 2014 format. Drawings shall comply with the University of Alabama CAD Standards.

1) The floor plan drawings shall indicate:

a) Location of all devices, circuits, end-of-line resistors (EOL), equipment, risers, and electrical power connections. Indicate the digital address or sequential zone/device number of all alarm initiating devices and notification appliances on each drawing.
b) Schedule outlining the number, size, and type of conductor and conduit used.

c) Point-to-point wiring connections showing individual circuits and circuit/conduit routing. This information shall be depicted in sufficient detail to locate readily specific conduits, raceways and circuits in the field and to identify the specific conductors/circuits contained therein. All penetrations of fire rated barriers shall be individually noted. French curve routing is not acceptable for depicting new conduits, raceways and circuits, or for depicting existing conduits, raceways and circuits whose detailed routing can be determined without demolition of existing construction.

d) Typical wiring diagrams for all alarm initiating devices and notification appliances, showing the size and type of conductors, wiring terminations, and terminal identifications.

e) Show wire routing and point of connection (location) to the building power circuit including identification of the circuit breaker for all fire alarm equipment.

f) Conduit fill calculations, in chart form, indicating the cross-section area percent fill for each type of wire/cable in each size of conduit used in the system. A maximum of 40% fill is allowed.

2) The riser diagram shall indicate:

a) Number, size, and type of riser conduits/raceways.
b) Number, size, and type of conductors in each riser.
c) Number of each type of device on each circuit on each floor.

c. Detailed wiring diagrams for all alarm control panels, voice evacuation panels, public address panels, firefighters' telephone panels, control panel modules, power supplies, electrical power connections, auxiliary function relays and solenoids, remote signaling equipment, video display units, and remote annunciators identifying all required terminations including terminal identifications. All unsupervised connections and terminations shall be noted "unsupervised."

1) These diagrams shall depict and identify all circuit boards, modules, power supplies, standby batteries, wiring harnesses, terminal strips and connections thereto, including spare zones and circuits. Where multiple components of a similar type are provided, each shall be identified by a unique component number.

2) These diagrams shall include front-view details of all control panels and annunciators, depicting and identifying all indicators, controls and zone labels, including proposed nomenclature.

3) These diagrams shall depict the required information to relative scale, actual size or larger, showing proper spatial relationships between components, and shall reflect the corresponding system components as they are to be installed.

d. Standby battery capacity calculations. Battery calculations shall list the type of devices (UPS, detection, monitoring, and control), notification appliances,

and modules; quantities, unit and extended amperage draw for quiescent and alarm conditions, total amperage draw and battery amp/hour rating. For design criteria, the calculated load shall be the design load, including the required 20% spare capacity. In addition, the battery capacity used to meet the calculated load shall be a maximum of 80% of the amp/hour rating listed by the manufacturer.

1) Amplifier capacity calculations showing sizing capable of powering all speakers simultaneously while operating at 80% of their rated capacity. Power supply capacity calculations showing that the power supplies are capable of powering all modules and devices shall be provided.
2) Power supplies for audible/visible notification shall be sized to support 120% of the number of appliances provided.

e. Voltage drop calculations shall be provided for all notification appliance circuits. Voltage drop at the last appliance shall not exceed 15% from the starting voltage.
f. A complete zone/address list identifying each signal initiating zone, annunciator zone, notification signaling zone, remote signaling and auxiliary function zone and the specific devices associated with each zone.

3. Each drawing shall be cross-referenced to all related drawings and specific drawing details as necessary for the submittal as a whole to depict clearly the proposed installation. Each drawing shall show revision number and date indicated in the title block. Revisions shall be clouded or otherwise highlighted between submissions. Revisions made without clouding or other highlights will not be reviewed and any approval of the revised drawings will not apply to those unnoted revisions.
4. The Contractor will not be authorized to start installation until all of the shop drawings and data sheets are received, reviewed and approved in writing by the Owner, the Owner's Consultant, the Alabama Building Commission, and the Tuscaloosa Fire and Rescue Service.

G. Operation and Maintenance Manual:

1. The Contractor shall provide the Owner with a loose-leaf manual containing:

a. A detailed description of the system and its operation including operator responses. The approved sequence of operation shall be placed in, or adjacent to, the operator's control panel.

b. A detailed description of routine maintenance required (by manufacturer and/or NFPA), recommended, or as would be provided under a maintenance contract including a testing and maintenance schedule and detailed testing and maintenance instructions for each type of device installed.
c. Manufacturer's data sheets and installation manuals/instructions for all equipment installed.
d. A list of spare parts provided including type of device and model number.

e. Service directory which includes the main 24-hour emergency service number and at least three alternate numbers which are monitored on a 24-hour basis. Also include the names of at least three (3) NICET Level II technicians qualified to provide emergency service during the guarantee period.

2. Within 90 days of authorization to proceed, the Contractor shall submit to the Owner four (4) copies of the draft manual for approval.
3. Thirty (30) days prior to completion of the work, four (4) copies of the approved manual shall be delivered to the Owner.
4. This manual shall be written, compiled and edited specifically for this project and the system installed. Unedited manufacturer's catalog data sheets and/or equipment manuals are unacceptable as content for this submittal.
5. Provide Operation and Maintenance Manual contents on a properly formatted and indexed Compact Disk (CD).

H. Contractor Record Drawings:

1. The Contractor shall provide and maintain on the site an up-to-date record set of approved shop drawing prints (red line) which shall be marked to show each and every change made to the fire alarm system from the original approved shop drawings. This shall not be construed as authorization to deviate from or make changes to the shop drawings approved by the Owner without written instruction from the Owner in each case. This set of drawings shall be used only as a record set.
2. Upon completion of the work, the record set of prints shall be used to prepare complete, accurate final record drawings reflecting any and all changes and deviations made to the fire alarm system.
3. Upon completion of the work, two sets of record drawings shall be submitted to the Owner' Consultant for review.
4. The contractor record drawings are required to show and to identify quantities of junction boxes, spare conductors, color coding of conductors, splices, device back boxes, and terminal strips. These drawings shall include a schedule of all connections/terminations, indexed by junction box, device back box and terminal strip and shall reference wire identification taped numbers as installed.
5. Provide contractor record drawings on index compact disk (CD) in AutoCAD Release 2014 format.

I. Drawing and Approval by Code Authority:

1. The Contractor shall provide the Owner's Representative with two copies of all documents that are reviewed and approved by the local code authority. These documents shall include, but not be limited to, the following:

a. Site inspection forms.
b. Permit/Shop drawings.

c. Final inspection/test forms or reports.

2. All documents must include all required approval stamps; signatures or other information necessary to properly certify the design, installation and system performance has been reviewed and accepted by the Alabama Building Commission, Tuscaloosa Fire and Rescue Service, and the University of Alabama Facilities.
3. Prior to installation, the contractor shall submit complete shop drawings to the Alabama Building Commission, Tuscaloosa Fire and Rescue Service, and the University of Alabama Facilities for review and approval. Allow two (2) weeks for review by the University of Alabama. Upon approval, a copy of the submittal shall be forwarded to the Owner.

J. Test Record:

1. System certification and documentation of system testing required herein shall be submitted to the Owner's Consultant for review and approval at least 14 days prior to the final acceptance test.

1.8 GUARANTEE

A. Guarantee Period:

1. The Contractor shall guarantee all materials and workmanship during the installation period and for a period of one year, beginning with the date of final acceptance by the Owner. The Contractor shall be responsible during the design, installation, testing and guarantee periods for any damage caused by him or his subcontractors or by defects in his or his subcontractors' work, materials, or equipment.

B. Emergency Service:

1. The Contractor shall provide emergency repair service for the system, at no cost to the Owner, within four hours of a request for such service by the Owner during both the installation and the guarantee periods. This service shall be provided on a 24-hour per day, seven days per week basis.

1.9 FINAL APPROVAL AND ACCEPTANCE

A. Final approval and acceptance of the work will be given by the Owner when:

1. The complete system has been inspected, tested, and approved in writing by the Owner's Consultant and the Authority Having Jurisdiction.
2. All required submittals, including system operation and maintenance manuals, contractor record drawings, test reports, spare parts, special tools and training have been provided to, reviewed by, and accepted in writing by the Owner's Consultant.

PART 2 - DESCRIPTION OF THE SYSTEM

2.1 GENERAL

A. The system shall be of the addressable type.

B. All equipment and system components furnished and installed shall be new and listed by UL for their intended use. The equipment and system components shall be installed in accordance with the applicable codes and standards, the manufacturers' recommendations, and within the limitations of the UL listings. All equipment and system components shall be the standard product of a single manufacturer (unless approved by Owner's Consultant). Evidence of UL listing is required. All systems shall be UL-864 9th edition listed.

C. System components shall be modular in design to ensure future expansion capability of the system. Spare capacity shall pertain to quantities of devices, circuits, power supplies, amplifiers, conductor ampacities (size) and lengths.

D. The system shall have spare installed capacity enabling it to support a 20% increase in the number of initiating devices, and in the number of control and notification appliance circuits. Control cabinets, power supplies and amplifier capacities installed as a part of this work shall be sized accordingly. Spare cabinet and power supply capacity shall be evenly distributed throughout the system.

E. Electromagnetic Interference:

1. All fire alarm control equipment, devices, and wiring shall be protected against unwanted radiated electromagnetic interference (EMI) and radio frequency interference (RFI) which can interfere with normal system processing and possibly cause unwanted alarms.
2. The system shall be designed and installed to be unaffected by the operation of a hand-held portable radio (walkie-talkie) of 5 watts power generating capability, or cellular telephone, within 12 inches of any system device with all appropriate covers installed.

2.2 SYSTEM CONFIGURATION

A. Initiating Device Circuits shall be Class B, supervised with an end-of-line (EOL) resistor.

B. Signaling Line Circuits:

1. Circuits connecting only remote annunciation devices with the control panel or circuits only on one floor or zone shall be Class B Style 4 as described in NFPA 72.
2. Circuit risers or circuits serving more than one floor or zone shall be Class A Style 7 and described in NFPA 72. Provide isolation such that a fault on an individual circuit will not affect normal operation of the circuit riser.

3. Provide Class A circuits for all communications between transponders in dormitories.

C. Notification Appliance Circuits:

1. Notification appliance circuits shall be Class B Style Y, 2-conductor circuits when serving only one floor or zone as described by NFPA 72.
2. Circuit risers shall be Class A Style Z as described in NFPA 72.

D. Firefighters' Telephone Circuits, where required, shall be Class B, supervised with end-of-line resistors.

2.3 POWER SUPPLIES

A. All AC power connections shall meet the requirements of NFPA 72. The Contractor shall connect to the building electrical power panels and shall provide all necessary circuit breakers in the existing electrical distribution panels to serve all new remote control panels and power supply panels. Whenever possible, connections shall be to the building's designated emergency electrical power circuit.

B. All portions of the system, including notification power supplies shall be designed and equipped on standby (rechargeable) battery power, either directly or by provision of an uninterruptible power supply.

C. Upon failure of normal (AC) power, the affected portion(s) of the system shall automatically switch over to secondary power without losing any alarm, trouble or operator acknowledgment signals.

D. Operation of any portion of the system on secondary power shall annunciate as a trouble signal, identifying the inoperable power supply(ies).

E. Standby batteries shall have sufficient capacity to maintain all portions of the system in a normal, non-alarm condition for a minimum of 4 hours with an emergency generator or 24 hours without an emergency generator, after which it shall be capable of operating all notification appliances simultaneously for a minimum of 5 minutes for horn alarm systems or 15 minutes for voice alarm systems.

F. All standby batteries shall be continuously monitored by the system. Low battery and disconnection of battery power supply conditions shall immediately annunciate as a trouble signal, identifying the deficient batteries.

G. All power supplies shall be capable of recharging their associated batteries, from a fully discharged condition to a capacity sufficient to allow the system to perform consistent with the requirements of this section, in 24 hours maximum. Standby battery capacity may be increased to meet this requirement.

H. All batteries shall be maintenance-free type.

I. Design load connected to any power supply, amplifier, and batteries shall not exceed 80% of its rated capacity.

2.4 ANNUNCIATION

A. General:

1. The system shall be designed and equipped to receive, monitor, and annunciate signals from devices and circuits installed throughout the building.
2. Receipt of alarm, supervisory, and trouble signals shall activate integral audible devices at the control panel(s) and at each remote annunciation device.

    a. The integral audible devices shall produce a sound output upon activation of not less than 75 dBA at 10 feet.
    b. Alarm, supervisory, and trouble signals shall initiate recognizably different audible outputs. Supervisory and trouble signals may initiate the same audible output if distinction is by visible annunciation.
    c. Integral audible devices shall continue to sound until silenced by a system operator actuating a switch designated for that purpose.
    d. Receipt of subsequent alarm, supervisory, or trouble signals shall cause the integral audible devices to resound.

3. The system shall recognize, annunciate, and store in a memory log each and every instance of the following signals by time and date:

    a. Fire alarms.
    b. Supervisory alarms.
    c. Trouble conditions.
    d. Operator acknowledgment of annunciated signals.
    e. System reset.

4. All alarm signals, supervisory alarm signals and trouble conditions shall be annunciated by the control panel(s) and by each remote annunciation device. Operator acknowledgment of smoke detection signals and system reset shall be annunciated by the control panel(s).

B. Fire Alarm Signals:

1. Activation of the following devices shall be recognized and annunciated by the system as fire alarms:

    a. Manual fire alarm boxes.
    b. Open area system type smoke detectors, including spot-type, and beam-type.
    c. Heat detectors.
    d. Sprinkler waterflow alarm switches.
    e. Dry-pipe sprinkler system alarm pressure switches.
    f. Devices monitoring actuation of kitchen hood or special suppression systems.

g. Module input – zone of conventional initiating devices.

C. Supervisory Alarm Signals:

1. The following conditions shall be recognized and annunciated by the system as supervisory alarms:

a. Valve supervisory (tamper) switch actuation.
b. Duct-type smoke detector activation (latching condition).
c. Fire pump status per NFPA 20 based on the controller provided.
d. Emergency generator running, failure to start, and other supervisory conditions.
e. Devices monitoring condition or supervision of special suppression systems.
f. Residential bedroom smoke detectors.

D. Trouble Signals:

1. The system shall recognize and annunciate initiating device circuit (IDC), signaling line circuit (SLC), and notification appliance circuit (NAC) trouble conditions as required by NFPA 72 for the style of circuits utilized.
2. The system shall also recognize and annunciate the following trouble conditions:

a. Power supply trouble conditions as required by Specification Section "Power Supplies" herein.
b. Remote annunciation device trouble conditions as required by Specification Section "Annunciation Devices" herein.
c. Addressable detector off base, failure to report, dirty device, and so forth.

3. A smoke detector with automatic drift compensation feature requiring maintenance when it reaches 80% of its threshold limit for a period of 24 hours, or equivalent UL listed performance.

E. Operator Acknowledgment Signals:

1. Silencing of integral audible devices required by Specification Section "Annunciation" herein shall be recognized and annunciated by the system as operator acknowledgment of the signal displayed.

2.5 FIRE ALARM CONTROL PANEL (EXISTING)

A. Description of Equipment:

1. The fire alarm control panel shall be designed and equipped to provide the following:

a. A fire alarm control panel (FACP) of the following manufacturer and model number shall be furnished by the owner and installed by the contractor:

1) Simplex 4100ES

2. The FACP shall function as the system monitor and control points panel and provide manual control switches for control and selection of all control points. The Fire Alarm Control Panel shall include required modules (including microphone and handset) for voice (1-way) and firefighters' telephone system (2-way).

3. A visible alpha/numeric LCD display indicating current status of the entire system.
4. Standby power supplies capable of supporting all dependent devices and equipment as required by Specification Section “Power Supplies” herein.
   The system control unit shall have provision for an alarm verification feature for alarm signals received from smoke detectors.
5. Auxiliary relays to affect the following functions:

   a. Shut down air handling units upon detection of smoke.
   b. Elevator recall and elevator shunt trip.
   c. Stair pressurization fans.
   d. Smoke control fans.
   e. Opening of doors for make-up air.
   f. Damper operation.
   g. Release of magnetic door hold-open devices.
   h. Unlocking of access-controlled doors.

6. Devices or controls to effect reset of the system. The control panel(s) shall not be capable of being reset until all alarm conditions have been cleared.
7. One backup amplifier shall be provided for each set of primary amplifiers, and shall be equal to the highest rated (wattage) primary amplifier provided. The backup amplifier shall automatically transfer in place of the defective amplifier in a UL listed arrangement.
8. Pre-recorded field programmable digitized voice messages, alert and evacuation type, as selected by the Owner for emergency voice/alarm communication systems. Evacuation message shall comply with ANSI S3.41 in accordance with NFPA 72.
9. The control panel shall have a switch for silencing the visible and audible alarm notification appliances. The switch shall be key-operated or located within a locked cabinet. Upon activation, any existing alarm will be transferred to a visible indicator. Any subsequent alarms from other zones will operate the alarm notification appliances. If there is no alarm and the switch is in the "silence" position, a visible alarm indicator shall be lit and a trouble signal shall sound until the switch is restored to "normal." The panel shall also provide a common switch to disable audible and visible signaling appliances for test purposes. When activated ("silence" position) a system trouble signal shall be activated until the switch is returned to the "normal" position.
10. The data communication rate between the system CPU and associated annunciators, remote transmitting panels and addressable initiating devices shall be such that the time delay between activation of an alarm initiating device (excluding retarded waterflow switches) and activation of the associated

automatic notification appliance signaling and automatic auxiliary control functions shall not exceed 10 seconds.

B. Emergency Voice/Alarm Communication System:

1. The fire alarm control panel shall also contain controls for the building's emergency voice/alarm communication system consisting of:
2. Single channel, one-way emergency communication ("public-address") evacuation tone capability on an automatic or operator selectable zone-by-zone or "all-call" basis via the fire alarm speakers.
3. The public address system shall be installed using manufacturer-recommended cable and shall be provided for selective communication to any individual floor, zone, combinations of floors or zones, or for general emergency public address announcements throughout the building.
4. The system shall be electrically supervised against faults in speaker circuits and interface wiring, loss of power, module removal, or amplifier, tone generator or pre-amp failure.
5. Electrical failures shall be annunciated audibly and visually at the fire alarm control panels.
6. Amplifiers shall be sized to power all speakers simultaneously, while operating at a maximum of 80% of their rated capacity. Calculations of amplifier capacity shall be provided.
7. One backup amplifier shall be provided for each set of primary amplifiers and shall be equal to the highest rated (wattage) primary amplifier provided.
8. The backup amplifier set shall automatically transfer in place of the defective primary amplifier.
9. Floor or stair speaker zones to be addressed shall be manually connected to the system using speaker zone switches or an "All-Call" switch located at the fire alarm control panel.
10. Emergency public address voice messages shall have priority over all other audible signals on the selected floors.
11. Single, 2-channel, or 3-channel 1-way emergency communication capability on either an automatic or operator selectable zone-by-zone or "all-call" basis via the fire alarm speakers. Equipment shall be arranged so that speaker zones can be selectively addressed, individually, in any combination of individual zones or on "all-call" basis for "public address" paging, digitized voice message, or tone generator signals. For multi-channel requirements, it should be specified that this requirement is for simultaneous operation.

C. Two-way telephone communication system for use by the fire service with capability on a zoned, operator selectable basis via the firefighters' telephone system as follows:

1. The system shall be electrically supervised against faults in telephone circuits and interface wiring, and loss of power.
2. An LED identifying the zone shall light, and an audible signal shall sound at the central control panel when either a remote telephone is plugged into a remote telephone jack, or a remote telephone is lifted from its cradle in a circuit.

3. The remote telephone shall receive a standby indication signal until the telephone is accessed by the central control panel.
4. Operation of the respective telephone select switch shall establish communications between the selected telephone zone(s) and the central control panel.
5. A cabinet with five handsets shall be provided near the control panel.

D. Coordinate the location of the fire alarm control panel and associated appurtenances with the University of Alabama and the Tuscaloosa Fire and Rescue Department.

2.6 REMOTE CONTROL EQUIPMENT

A. Description of Equipment:

1. Remote transmitting panels shall:

a. Interface local initiating device and notification appliance circuits or addressable devices with the control panel(s) via the signaling line circuit riser(s).
b. Be provided primary and secondary power in accordance with Specification Section “Power Supplies”.
c. Contain amplifiers for speaker circuits, visible notification appliance circuit controls, addressable interface device boards, manual controls, firefighters' master handset, and microphone for speaker circuits, and secondary power supplies for all its associated interconnected equipment.
Upon loss of communications to the main control panel or peer control panels, the remote transmitting panel shall operate as a standalone fire alarm control panel.

2.7 ANNUNCIATION DEVICES

A. Description of Equipment:

1. System Annunciators:

a. Provide a remote LCD annunciator panel. The remote LCD annunciator shall be capable of displaying alarm supervisory, and trouble conditions on a device-by-device basis to replicate device descriptions at the control panel LCD display. The LCD display shall be capable of displaying a minimum of 80 alphanumeric characters over 2 lines.
b. LCD annunciator panel shall be programmed to display a clear description of the specific type of signals received, in the order and the time and date at which they are received, up to the capacity of the screen. Fire and supervisory alarm signals shall be displayed until the condition is cleared and the control panel reset. Trouble signals shall be displayed until the condition is cleared. Subsequent signals shall be stored and shall be displayed sequentially as the preceding signals are acknowledged.

c. The LCD annunciator panel shall not allow system resetting or silencing of the building initiating devices or notification appliances without the use of a key.

B. Coordinate the location of annunciation devices with the University of Alabama and the Tuscaloosa Fire and Rescue Department.

C. Annunciation device faults shall be annunciated as trouble conditions at the fire alarm control panel.

2.8 MANUAL FIRE ALARM BOXES

A. Description of Equipment:

1. Manual fire alarm boxes shall be of the double-action, non-coded type. They shall consist of a housing, fitted with a pull-down lever, which when operated, locks in position to effect activation of an initiating or signaling line circuit. The body of the manual fire alarm box shall be permanently attached to the back plate assembly. Resetting the station after operation shall require the use of a key or special tool. The manual fire alarm box shall be suitable for semi-flush mounting (no surface mounting allowed).
2. Addressable manual fire alarm boxes shall be factory assembled with the addressable module an integral part of the UL listed product.
3. Manual fire alarm boxes shall be installed so that the handle is 48 inches from the finished floor.
4. Manual fire alarm boxes installed in areas subject to physical damage shall be provided with UL listed protective wire or polycarbonate covers.
5. Manual fire alarm boxes installed in areas where false alarms are a concern, such as residential buildings, shall be provided with alarmed polycarbonate covers, such as those manufactured by Safety Technology International, Inc. (STI).

2.9 SMOKE DETECTORS

A. Description of Equipment:

1. Spot Type Smoke Detectors:

a. These detectors shall be:

1) System-operated, photoelectric type plug-in detectors that mount to a twist lock base shall be provided with a tamper-resistant feature to prevent unauthorized removal. The detectors shall contain an alarm initiating LED which will illuminate to signal activation of the detector. Detectors shall be listed by UL as "Smoke-Automatic Fire Detectors," tested according to UL 268. Detectors listed as "Single and Multiple Station Smoke Detectors," tested according to UL 217 shall not be used.

2) Each smoke detector shall be monitored individually, via an integral, analog addressable element.
3) Spot type smoke detectors shall be located such that they are not affected by airflow from the building's heating, ventilating, and air conditioning (HVAC) system. In no case shall spot type smoke detectors be located within 3 feet of supply or return diffusers.

2. Projected Beam Type Smoke Detectors:

a. Projected beam type smoke detectors shall monitor continuously over a given distance and shall consist of an integral transmitter and receiver units with a separate reflective plate. These detectors shall employ an obscuration detection principle using a projected, invisible, infra-red light beam.

b. Projected beam type smoke detectors shall be 4-wire type, powered from a separate, supervised 2-wire power circuit. Detector power circuits shall be supervised using an end-of-line power supervisory relay monitored by a dedicated, addressable monitor module.
c. Beam type smoke detectors shall incorporate automatic gain control to compensate for gradual signal deterioration resulting from dirt accumulation on lenses.

3. Duct Smoke Detectors:

a. Duct photoelectric type smoke detectors shall be installed on both the supply and return in all new and existing air handling systems over 2,000 CFM in accordance with the requirements of NFPA 72, NFPA 90A, the International Mechanical Code, local requirements, and the detector manufacturer's installation instructions. Duct smoke detectors shall be suitable for the full range of air velocity conditions in the air handling systems in which they are installed. Calculations or measurements of air velocities shall be provided to ensure duct detectors are installed within their UL listed range of air flow. Duct smoke detectors shall be installed in supply and return sides of air distribution systems. On the supply side duct detectors shall be provided on the common duct upstream of any branch connections or common plenums.
b. Duct smoke detectors shall be of the analog, addressable type, consisting of a plug-in detector head in a duct mounted housing equipped with metal air sampling tubes providing air flow through the detector housing. Duct smoke detectors shall be listed or approved for that application including temperature and humidity listings. Duct smoke detector operating voltage shall be (nominal) 24 VDC supplied by the fire alarm system.
c. Each duct smoke detector shall be monitored individually via an integral, analog addressable element.
d. These detectors shall be arranged to initiate shutdown of their associated fan and air handling unit on alarm from their associated addressable control relays.
e. Provide necessary interlock wiring to fan and air handling unit starters and motor control centers for shutdown of fans when smoke is detected.

f. Smoke detectors used solely for closing dampers shall not be required to activate the building evacuation alarm.
g. Sampling tubes shall extend across the full width of the duct. The ends of the sampling tubes shall be accessible from outside the duct and shall be sealed with removable plugs (to facilitate detector testing). Access hatches shall be provided to inspect sampling tubes.
h. Sampling tubes shall be metal and of the perforated type. Slot type sampling tubes shall not be acceptable. A short pick-up tube not extending across the widest dimension of the duct shall not be acceptable.
i. All duct smoke detectors shall be provided with a manually operated remote test station, incorporating a remote alarm LED. Test stations shall be labeled with engraved, laminated plastic labels identifying the type of detector and must be easily accessible.
j. Duct detectors shall be located 6 duct widths from any bends or inlets. Additionally, the must be located a minimum of 10’ downstream from humidifiers.

2.10 HEAT DETECTORS

A. Description of Equipment:

1. Heat detectors shall be low profile, combination rate-of-rise and fixed temperature type.
2. Heat detectors shall actuate when the temperature either increases at a rate exceeding 15°F per minute or reaches 135°F except where otherwise required by NFPA 72. (180°F where ambient temperature exceeds 100°F).
3. Addressable elements shall be integral to the detector.
4. Heat detectors for elevator power interrupt shall be provided and installed in sprinkler protected elevator machine rooms and hoistways in accordance with ANSI A17.1. Signals from the elevator machine room and hoistway heat detectors shall be annunciated on the building fire alarm system as "elevator heat detectors." Where heat detectors are used to shutdown elevator power prior to sprinkler operation, the detector shall have both a lower temperature rating and a higher sensitivity as compared to the sprinkler.

2.11 SPRINKLER SUPERVISORY AND ALARM EQUIPMENT

A. All sprinkler alarm and supervisory devices are either existing or shall be installed by others. These devices will be located as indicated on the drawings and include:

1. Waterflow alarm switches.
2. Dry-pipe sprinkler system alarm pressure switches.
3. Valve supervisory (tamper) switches.
4. High-Low supervisory air pressure switches (on dry or pre-action sprinkler systems only).
5. Fire pump status as required by NFPA 20.

B. Sprinkler supervisory devices shall be connected to the fire alarm system and monitored.

C. Waterflow alarm switches and alarm pressure switches shall be monitored as fire alarm signals. All other sprinkler supervisory devices shall be monitored as supervisory signals.

D. The Contractor shall make all terminations necessary to monitor sprinkler supervisory devices, except for terminations between the fire pump controller and the fire alarm system terminal interface, which shall be provided by others and will depend on the capabilities of the existing controller.

E. The Contractor shall coordinate with the Sprinkler Contractor and the Owner's Representative for testing these devices. Documentation of sprinkler supervisory device testing shall be a part of this contract.

2.12 DOOR HOLDERS

A. Magnetic door holders shall have an approximate holding force of 25 pounds.

B. The door portion shall have a stainless steel pivotal mounted armature with shock absorbing nylon bearing.

C. Unit shall be capable of being either surface, flush, semi-flush, or floor mounted as required.

D. Door holders shall be UL listed for their intended purpose.

E. Door holders shall be either 24VDC or 120VAC.

2.13 ADDRESSABLE CIRCUIT INTERFACE MODULES

A. The Contractor shall provide, install, and test addressable circuit interfaces as necessary to comply with the cause and effects matrix, whether shown on the engineering drawings or not.

B. All circuit interfaces used for supervisory or control functions shall be mounted within 3 feet of this monitored switch or circuit. The control relay shall not be required to be within 3 feet of the circuit when failure results in the operation of devices in a "Fail-safe" mode.

2.14 AUDIBLE/VISIBLE NOTIFICATION APPLIANCES

A. Description of Equipment:

1. Notification appliances shall consist of an audible component (fire alarm speaker), a visible component (amber and clear strobe), or a combination of the two

appliances. Ceiling-mounted appliances shall be white. The color of wall- mounted appliances shall be red.

2. Notification appliances installed in areas subject to physical damage shall be installed with protective covers as recommended by the manufacturer.
3. Audible notification appliances shall be installed, spaced and tapped (when speakers are provided) so as to produce a sound output on alarm which is clearly audible above the ambient noise level throughout the building. In no case shall the audible alarm be less than 15 dBA above the ambient room noise level or less than 5 dBA above the maximum ambient noise level. In no case shall the audible sound output exceed 110 dBA.

    a. Fire Alarm Speakers shall:

        1) Be listed in accordance with UL 1480.
        2) Have multi-taps with a minimum range from ¼-watt to 2 watts. Speakers shall be sized, spaced and tapped to provide a sound output, on alarm, of no less than 15 dBA above ambient sound levels.
        3) Speakers shall be located throughout to provide a minimum of 15 dBA above ambient in all areas designated as public mode notification zones. Speakers shall also be provided in all exit stairways. Each exit stairway shall be zoned individually and be capable of manual control. Speaker zones for individual floors shall not include exit stairways.

    b. Visible Notification Appliances:

        1) Visible notification appliances shall be a minimum of 15 and maximum of 185 candela.

        2) Visible notification appliances shall consist of a Xenon flash tube, high intensity strobe lamp, with clear (nominal white) light having a flash rate of 1 to 3 flashes per second. The maximum pulse duration shall be 2/10's of one second (0.2 seconds), with a maximum duty cycle of 40%. The pulse duration is defined as the time interval between initial and final points of 10% of maximum signal.
        3) Visible notification appliances shall be listed for the specific application of wall mounted or ceiling mounted. When mounted on the wall, the word “Fire” shall read from top to bottom. When mounted on the ceiling, the word “Fire” shall read left to right.
        4) Wall mounted visible notification appliances shall be mounted not less than 80 inches above the finished floor, or 6 inches below the ceiling, whichever is lower.
        5) Ceiling mounted visible notification appliances shall be located in accordance with NFPA 72.
        6) Placement of visible notification appliances in rooms and corridors more than 20 feet wide shall be in accordance with NFPA 72 for room configurations.
        7) Placement of visible notification appliances in corridors 20 feet or less in width shall be in accordance with NFPA 72 for corridor spacing.

8) Placement of visible notification appliances in accessible sleeping rooms shall be in accordance with NFPA 72 Table 7.5.4.4.2 for sleeping rooms.

   a) For installation of visible notification appliances equal to or greater than 24 inches from the ceiling, the intensity shall be 110 cd.
   b) For installation of visible notification appliances less than 24 inches from the ceiling, the intensity shall be 177 cd.

9) Shall be installed in all public or general areas including but not limited to, public restrooms, meeting rooms, dining rooms, classrooms, copy rooms, conference rooms, assembly areas, common laboratories, common areas, corridors, and offices. Spacing and layout shall be as required by ADAAG and NFPA 72.
10) Amber and clear speaker strobes required in restrooms.
11) Visible notification appliances shall be listed in accordance with UL 1971.
12) Visible appliances shall activate anytime audible appliances are activated. This activation shall occur when an audible notification appliance circuit is activated manually or automatically without operating additional switches.
13) More than two strobes within the same view (135°) shall be synchronized in accordance with NFPA 72.
14) All strobes shall be amber and clear.
15) All strobes shall be addressable type.
16) All Notification Appliances shall operate as a completely independent device allowing for specific location alerting of both fire alarm and Mass Notification functions. Each visible device (both clear and amber mass notification) shall be capable of operating on multiple notification zones or completely separate from all other notification devices, this allows “On the fly” program operation changes for Mass Notification alerting and fire alarm notification.

2.15 FIREFIGHTERS’ TELEPHONE EQUIPMENT

A. Telephone Jacks:

   1. Where required, telephone jack stations shall be provided at stair entrances, elevator lobbies, elevator cars, and the fire pump room where provided.
   2. Telephone jack stations shall be a single gang, stainless steel plate with engraved identification as "Fire Emergency Phone Jack".

B. Telephone Cabinets:

   1. Telephone cabinets shall be provided in enclosed stairs at every fifth level, exit corridors, elevator lobbies, and the fire pump room, where provided, as indicated on the drawings.

2. Telephone cabinets shall be provided with key locked (keyed alike with fire alarm control panel key and manual fire alarm station key) and break glass panel.
3. Cabinets shall be flush, semi-surface, or surface mounted as approved by the Owner.
4. Cabinets shall have a polished stainless steel or painted red finish with silk screened identification as "Emergency Telephone".
5. Telephone connected cable shall be a security type armored cable.
6. Cabinet shall be provided with an LED call indication light, which lights when the station is connected to the communication control panel.

2.16 CONDUCTORS AND RACEWAY

A. Except as otherwise required by Code and/or these Specifications, the installation of fire alarm circuits shall conform to the requirements of Article 760 and raceway installation to the applicable sections NFPA 70, National Electrical Code. Fire alarm circuit wiring shall include all circuits described in Section 760.1 including Fine Print Note No. 1 (FPN No. 1).

B. Non power-limited fire alarm (NPLFA) circuits shall have overcurrent protection and be installed in conformance with Parts I and II of Article 760 and the applicable requirements of NFPA 70.

C. Power-limited fire alarm (PLFA) circuits shall be installed in conformance with Parts I and III of Article 760. The power sources for PLFA circuits shall meet the requirements of Section 760.121 and the equipment supplying power shall be durably marked as required by Section 760.124.

D. Power-limited circuits which are reclassified as non-power-limited circuits shall meet the requirements of Part II of Article 760, including overcurrent protection, and shall have the marking required by Section 760.124 eliminated. Reclassified circuits shall remain non-power-limited throughout their entirety.

E. Fire alarm circuits installed in locations other than ordinary indoor, dry locations shall be in conformance with Sections 760.3 and 760.32 with conductor or cable types suitable for the installation conditions.

F. Separation of circuits shall be in conformance with Section 760.48 for NPLFA circuits and Section 760.133 for PLFA circuits.

G. Nonpower-limited circuit (NPLFA) conductor sizes, insulation types and installation methods shall be as limited by Sections 760.49, 760.51 and 760.53.

H. Power-limited circuit (PLFA) wiring material and installation methods shall be cable listed and marked in accordance with Section 760.179.

I. All fire alarm circuits shall be installed in red conduit by methods permissible in NFPA 70.

J. All circuit runs shall be continuous between devices, without splices, wherever feasible. Where a continuous run is not feasible, connections shall be made in a UL listed metal electrical box.

K. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

L. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

M. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices.

N. Wire and cable shall be sized, twisted and shielded as recommended by the fire alarm system manufacturer, and shall meet the requirements of Article 760 of NFPA 70, National Electrical Code.

O. All conduit shall be grounded by approved ground clamps or other means in conformance with the National Electrical Code.

P. Where conduit is imbedded in plaster, the Contractor shall use a type approved by the National Electrical Code for this use. All joints in such imbedded conduit shall be liquid and gas-tight.

Q. Continuous run of conduit without joints is preferred for imbedding.

R. All electrical enclosures, raceways and conduits shall contain only those electrical circuits associated with the fire alarm system and shall not contain any circuits that are unrelated to the system.

S. Cables and conductors having scrapes, nicks, gouges, or crushed insulation shall not be used.

T. The use of aluminum wire is prohibited.

U. All electrical circuits shall be numerically identified at both ends with machine-generated labels. Label in panel with panelboard and circuit numbers. Provide lock on breaker for 120V fire alarm panel circuit.

V. All system conductors, except grounding conductors, shall be stranded copper.

W. All end-of-line resistors shall be mounted on terminal blocks.

X. All underground wiring shall be fire alarm listed suitable for direct burial, such as West Penn Aquaseal or Belden equivalent. All wiring shall be installed in liquid-tight PVC conduit with no splicing below ground. Provide additional ground wire within conduit to maintain reference ground on system between buildings.

Y. All conduit, junction boxes, and enclosures subjected to moisture shall be weatherproof (NEMA 3, 4, or 4X) as required.

Z. All conductor shielding shall be continuous (with splices) for the length of the circuit and shall be grounded at the associated control panel only.

AA. Shield drain conductors and foil shall be trimmed and taped at each splice to prevent grounding of the shield at any location other than the associated control panel.

2.17 BOX LOCATION

A. All device backboxes, junction boxes and pull boxes shall be accessible for inspection and maintenance.

B. Junction pull boxes shall be installed on 100 foot centers maximum.

C. Terminal cabinets installed outdoors or in areas subjected to moisture shall be weatherproof (NEMA 3R) and shall be installed no less than 18-inches above grade. In areas subject to lightning, terminal strips shall be isolated from the enclosure by non-metallic base plates to prevent arcing of contacts to enclosure. Boxes shall also be grounded using approved grounding rods.

2.18 SPARE PARTS

A. The Contractor shall supply as part of this contract, the following spare parts:

1. Automatic detection devices – Two each.
2. Manual fire alarm boxes – Two each.
3. Audible and visible appliances – Four each of the different types.
4. Keys - A minimum of three sets of keys shall be provided and appropriately identified.

2.19 TRANSIENT SUPPRESSION

A. Transient suppression shall be provided for each circuit connected to the Fire Alarm System that enters or exits the building housing the fire alarm control panel. Provide and install in accordance with NFPA 780.

B. Catalog data sheets for the transient devices installed shall be included in the submittal. Each device shall be noted on the data sheets as UL listed to operate on the circuit (120V, SLC, NAC, IDC, etc.) for which it is being employed.

C. The installation of transient suppression shall be at a location that facilitates maintenance and inspection and is adjacent to the point of exit or entry to the building for all low voltage circuits. The suppression devices shall be installed in junction boxes that are sized to house the suppression module and the terminal blocks which interconnect them to the fire alarm circuits.

D. Surge arrestors on surge suppression devices which are integral to FACP components or circuit boards shall not be considered “as-equal” to this requirement for individual dedicated circuit protection.

PART 3 - EXECUTION

3.1 STARTING AND COMPLETION DATES

A. The starting and completion dates for this work will be established at the pre-bid meeting.

3.2 INSPECTION

A. The job site supervisor shall examine daily all areas in which the work will be performed on the day prior to beginning work. The supervisor shall immediately report unsatisfactory working conditions to the Owner for resolution. The supervisor shall not proceed with the work until all unsatisfactory working conditions have been corrected.

3.3 INSTALLATION

A. General:

1. All wires and cable shall be installed in red conduit (3/4” minimum) to include electrical metallic tubing (EMT), flexible metallic conduit (FMC) (not less than ½”), or surface metal raceway (700 minimum). Conduit installed in areas subject to physical damage shall be rigid metal conduit (RMC). PVC conduit (Schedule 80) shall be used in areas subject to moisture or other areas where corrosion is a concern.
2. All holes made by the Contractor in any wall, ceiling or floor shall be patched by the Contractor, restoring the walls, ceilings, and floors to their original condition, fire resistance and integrity.
3. Removal and repair of all finished surfaces shall be coordinated with the Owner and is subject to his approval. Repair of surfaces will be evaluated by the university architect on a case-by-case basis.
4. All piping and conduit shall be installed at a height so as not to obstruct any portion of a window, doorway, stairway or passageway, and shall not interfere with the operation of any existing mechanical or electrical equipment.
5. System riser(s) shall be installed in mechanical raceways or conduit, located to avoid physical harm. They shall be routed through protected spaces, such as electrical closets. Locations such as loading docks and less than 7 feet above the floor in elevator lobbies shall be avoided.

6. Locations of all equipment, controls and system components are subject to the approval of the Owner.

7. Contractor is responsible for protecting both new and existing smoke detectors during construction. These detectors shall be covered during construction. All such covers shall be removed upon completion of work.
8. All work shall be carefully scheduled with all departments of the University of Alabama that utilize the specific building to avoid disruption to daily operations or scheduled events.
9. All systems, components, equipment, devices, conductors, and other fire protection appurtenances shall be installed and dressed in a workman-like manner, so as to maintain such equipment readily identifiable, accessible and serviceable. Any equipment not installed in this manner will be replaced and reinstalled at the Contractor's expense and to the satisfaction of the Owner.
10. Provide machine-generated labels on all devices to identify clearly the associated device address (yellow with black letters). The label appearance and proposed placement on devices shall be coordinated in advance with the Owner.

B. Concealment:

1. All conduit, raceways, junction boxes and device backboxes shall be concealed in walls, ceiling spaces, electrical shafts or closets in all finished areas. Conduit, raceways, junction boxes and device backboxes may be exposed in unfinished back-of-house areas or mechanical equipment rooms.
2. Surface metal raceway (i.e., wire mold, conduit) is permitted in finished areas where approved by the Owner on a case-by-case basis. Locations where metal raceway is proposed shall be clearly identified on the contractor's shop drawings.
3. Exposed conduit, raceways, junction boxes and equipment backboxes permitted to be install by the owner shall be painted to be as inconspicuous as possible. The Owner shall approve the paint color selected. The Contractor shall prepare color samples for inspection by the Owner prior to painting.
4. Accessible conduit, raceways, junction boxes, and other associated items related to the conduit network shall be red with junction box covers labeled as fire alarm (red with ¼" white letters), unless specifically instructed otherwise.

3.4 TESTING

A. System Tests:

1. The Contractor shall provide the Owner with written certification that all equipment:

    a. Has been inspected and tested by a manufacturer's certified representative.
    b. Is installed in accordance with the manufacturer's recommendations and UL listings.
    c. Is in proper working order.
    d. The Contractor shall provide completed Inspection and Testing forms as outlined in NFPA 72.

B. Acceptance Testing:

1. Upon completion of the installation or each installation phase where applicable, the Contractor shall perform and document on an approved format, system tests as required herein. All acceptance tests shall be performed in the presence of the Owner or his designated representatives.

    a. All conductors, including shielding conductors, shall be tested for continuity, shorts to ground and shorts between pairs.
    b. All remote transmitting panel monitor points shall be functionally tested and monitor point identifications verified.
    c. All alarm initiating devices shall be functionally tested. This includes all smoke detectors, heat detectors, and manual fire alarm boxes.
    d. All supervisory functions of each initiating device circuit, signaling line circuit, and notification appliance circuit shall be functionally tested.
    e. All notification appliances shall be checked for proper operation with the voltage measured at the last appliance on each of the notification appliance circuits.
    f. The strobe intensity (candela rating) and synchronization of all visible notification appliances shall be verified.
    g. All fire safety functions (e.g., elevator recall, smoke control, door unlocking) initiated by the fire alarm control panel shall be tested.
    h. Receipt of all alarm, supervisory, and trouble signals, initiated during the course of the testing shall be verified at each annunciation device.
    i. Correct labeling of all annunciation device LED's shall be verified.
    j. Sound level tests shall be performed in at least 10% of rooms on each floor and all corridors to verify minimum conformance with NFPA 72 and ADA requirements.
    k. Correct annunciation of all points shall be verified.
    l. Standby batteries shall be load tested to confirm compliance with the approved design capacity.
    m. Any additional tests, required by the referenced codes, standards, or criteria, or by the Owner, shall be performed.
    n. Documentation of such tests shall include:

        1) The date and time of each test.
        2) A reference set of contractor record drawings, numerically identifying the individual components and circuits tested, test locations, and indicating the measured sound level in each location.
        3) A description of each test performed.
        4) A checklist of each device and circuit tested, indicating the results of each test.
        5) The names and signatures of the individuals conducting and witnessing each test.

2. Final Inspection and Tests:

a. The Contractor shall make arrangements with the Owner's Representative for final inspection and witnessing of the final acceptance tests. The Owner's Representative and The Owner's Consultant will witness the final acceptance test.

1) When local code authorities are required to witness tests, the Contractor shall be responsible for making all necessary arrangements with the code authorities and coordinating the work with the Owner's Representative and Owner's Consultant.
2) The Contractor shall be responsible for obtaining all test documents with necessary approval stamps and signatures of the code authorities. The Contractor shall submit copies of each of these documents to the Owner's Consultant.

b. If after being advised by the Contractor that the work is completed and ready for test, the work has not been completed or the final acceptance tests are unsatisfactory, the Contractor shall be responsible for the Owner's extra expenses for re-inspection and witnessing the retesting of the work and additional reporting documentation. Such extra fees shall be deducted from the payments made by the Owner to the Contractor.
c. The Contractor shall provide at least five working days notice for all tests.

3.5 MATERIAL HANDLING

A. Storage:

1. The Owner will provide the Contractor with a lockable storage space for the Contractor's use during this project. The Contractor shall be responsible for the security of this space.
2. Overnight storage of materials is limited to the assigned storage area. Materials brought to the work area shall be installed the same day,or returned to the assigned storage area unless previously approved by the Owner.

B. Receiving and Handling:

1. The Contractor shall be responsible for all receiving, handling, and storage of his materials at the job site.
2. Use of loading docks, service driveways, and freight elevators shall be closely coordinated with the Owner.

C. Rubbish Removal:

1. The Contractor shall remove rubbish and debris resulting from his work on a daily basis. Rubbish not removed by the Contractor will be removed by the Owner and back-charged to the Contractor.
2. Removal of debris and rubbish from the premises shall be coordinated with the Owner.

END OF SECTION 28 31 00

SECTION 31 6615
HELICAL FOUNDATIONS PILES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Helical piles used to support compression loads.

1.02 PRICE AND PAYMENT PROCEDURES

A. Base bids on anchor/pile quantity and lengths as indicated.

B. If the actual number of installed anchors/piles or the total installed length differs, an adjustment to the Contract Sum will be made based on unit prices defined in the Agreement.

C. No additional payment will be made for withdrawn, damaged, rejected, or misplaced piles; for any portion of a pile remaining above the cut-off elevation; for backdriving; for cutting off piles, or for any cut off length of piles.

D. Quantity and length measurements will be determined by Installation Logs kept and submitted by Architect and verified by Contractor, based on the following:
   1. Length: By the linear foot measured from point to existing site elevation as indicated.
   2. Test Anchors/Piles: Assume 5 feet longer than longest designed length.

1.03 DEFINITIONS

A. Specific terms used in this section are defined below. Terms not defined below are defined in DFI TM-GLOS-1 first and then by common usage.

B. Extension Section: Helical foundation component installed between lead section and load transfer device.

C. Effective Torsional Resistance: Average installation torque typically taken over a distance equal to last three diameters of penetration of largest helix plate.

D. Geotechnical Capacity (or, Ultimate Soil Capacity): Maximum load resisted.

E. Lead Section: First helical foundation component installed in soil.

F. Limit State: Condition beyond which a helical foundation component is unfit for service.
   1. Serviceability Limit State: Foundation no longer useful for its intended function.
   2. Strength Limit State: Foundation is unsafe.

G. Loads: Forces or other actions that result from weight of all building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are those loads in which variations over time are rare or of small magnitude. All other loads are variable loads (see also Nominal Load below).

H. Load Test: Procedure to test capacity and relation of load to movement.

I. Mechanical Strength: Maximum tension load resisted by structural elements of helical foundation.

J. Nominal Load: Magnitude of loads determined by Architect, including dead load, live load and other imposed by building code requirements

K. Reveal: Distance along longitudinal axis from ground surface to end of last installed extension of a foundation.

L. Safety Factor: Ratio of ultimate pullout resistance to nominal load.

M. Ultimate Pullout Resistance: Limit state based on lesser of mechanical strength or geotechnical capacity and defined as point at which helical foundation can resist no additional load.

1.04 REFERENCE STANDARDS

A. AISC 360 - Specification for Structural Steel Buildings; 2016.

B. ASTM A29/A29M - Standard Specification for Steel Bars, Carbon Alloy, Hot-Wrought, General Requirements; 2016.

C. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.

D. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.

E. ASTM A500/A500M - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes; 2018.

F. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel; 2018.

G. ASTM D1143/D1143M - Standard Test Method for Deep Foundations Under Static Axial Compressive Load; 2007, with Editorial Revision (2018).

H. DFI TM-GLOS-1 - Deep Foundation Institute Technical Manual; Glossary of Foundation Terms; 1981.

I. SAE J429 - Mechanical and Material Requirements for Externally Threaded Fasteners; 2014.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation meeting: Conduct a preinstallation meeting one week prior to start of work of this section; require attendance by all affected installers.

1.06 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Product list, with manufacturer's model designations; published capacities for installed assemblies, including load transfer devices.

C. Design Data: Submit documentation of foundation design, signed and certified by foundation designer; include:
   1. Statement that proposed foundations meet specified design criteria.
   2. Nominal load on each foundation element.
   3. Maximum allowable installation torque of each selected product.
   4. Calculated theoretical geotechnical capacity.
   5. Minimum effective torsional resistance requirements.
   6. Minimum embedment lengths and such other site specific embedment depth requirements.
   7. Inclination angle and location tolerance requirements.
   8. Pre-tensioning requirements, if any.
   9. Submit not less than four weeks prior to start of foundation installation.

D. Calibration Reports for Testing Equipment: Submit certified copies of calibration of torque measuring equipment and load test measuring equipment to be used on project, performed within one year of starting date of installation.

E. Designer's Qualification Statement.

F. Installer's Qualification Statement.

G. Surveyor's Qualification Statement.

H. Installation Logs:
   1. Submit a copy of the log of each individual foundation element within 24 hours after installation is completed.
   2. Submit final copy of all installation logs within two weeks after completing all helical foundation work.

I. Field Test Reports.

J. Project Record Documents: After work is complete, submit certification from surveyor that installed foundation locations are as shown on drawings.

1.07 QUALITY ASSURANCE

A. Designer Qualifications: Experienced in design of helical foundations of the type involved on this project, as evidenced by:
   1. State registration/licensure as a professional engineer.
   2. Recognition by local authority having jurisdiction.
   3. List of three or more similar projects designed within the previous three years and names of project representatives who can verify such participation.
   4. Manufacturer's written recommendation.

B. Installer Qualifications: Experienced in installation of helical foundations of the type involved on this project, as evidenced by:

C. Surveyor Qualifications: Engineer or land surveyor licensed in the State in which the Project is located.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Helical Piles and Anchors:
1. Chance®; Hubbell Power Systems
2. MacLean Civil Products
2. Substitutions: See Section 01 6000 - Product Requirements.

2.02 HELICAL FOUNDATION DESIGN CRITERIA

A. It is Contractor's responsibility to design, or obtain qualified design, of the helical foundations as indicated in Contract Documents.
1. Information necessary for design that is contained in Contract Documents includes:
a. Locations of foundation elements.
b. Nominal design load for each foundation element, including dead load, live load and other loads required by building codes.
2. Subsurface geotechnical data may be obtained from 1999 16th Street Baptist Church Subsurface Investigation Report prepared by Gallet & Associates included for reference in this Project Manual..

B. Helical Foundation Elements: One or more helical deformed plates (helix plates) attached to a central shaft with a load transfer device for attachment to a structure; entire element resisting applied loads by soil pressure.
1. Design foundations to support/resist the nominal design loads shown on drawings in accordance with AISC 360, Allowable Stress Design method.
2. Select foundation elements based on allowable installation torque and calculated minimum embedment length; maximum embedment length, if any; and minimum effective torsional resistance.
3. Corrosion Service Life: 50 years, minimum.
4. Use solid square shaft helical anchors where subject to tension alone.
5. Use hollow, round shaft helical foundations where subject to compression only or to alternating tension and compression.

C. Helical Anchors:
1. Base design on published capacities that represent entire anchor including couplings and connections.
2. Safety Factor: 5 times ultimate pullout/bearing resistance, minimum.

D. Helical Piles:
1. Design with pile shaft sections in direct contact with couplings and no coupling bolts or welds in load path.
2. Safety Factor: 2 times ultimate bearing resistance, minimum.
3. Deflection: As indicated on drawings.
4. Fit Up Tolerance: 1/16 inch, maximum.

2.03 MATERIALS

A. All Components: Hot-dipped galvanized in accordance with ASTM A123/A123M.

B. Helical Anchors: Solid, square shaft of hot rolled, solid, Round-Cornered-Square (RCS), carbon steel bar complying with ASTM A29/A29M.
1. Size: 1-1/2 inch square.
2. Torque Strength: 6,000 foot-pounds.
3. Minimum Yield Strength: 90 kips per square inch.

C. Helical Anchors and Piles: Hollow, round shaft of structural steel tube or pipe (rolled) complying with ASTM A572/A572M.
1. Size: 2-7/8 inches O.D. by 0.203 inch wall thickness.
2. Torque Strength: 6,000 foot-pounds.
3. Minimum Yield Strength: 60 kips per square inch.

D. Helical Anchors and Piles: Hollow, round shaft of structural steel tube or pipe (welded or seamless) complying with ASTM A500/A500M.

1. Size: 2-7/8 inches O.D. by 0.276 inch wall thickness.
2. Torque Strength: 8,000 foot-pounds.
3. Minimum Yield Strength: 60 kips per square inch.

E. Helical Anchors and Piles: Hollow, round shaft of structural steel tube or pipe (rolled) complying with ASTM A572/A572M.
1. Size: 3-1/2 inches O.D. by 0.313 inch wall thickness.
2. Torque Strength: 16,000 foot-pounds.
3. Minimum Yield Strength: 65 kips per square inch.

F. Helix Plates: Round steel plates formed into helical spiral on matching metal dies to true helical shape and uniform pitch; welded to central shaft with all plates tracking the same path as leading helix.
1. Material: Hot rolled carbon steel sheet, strip, or plate complying with ASTM A36/A36M or ASTM A572/A572M, Grade 50.
2. Thickness: 3/8 inch
3. Profile: True helix-shaped plates, normal to shaft, leading and trailing edges within 1/4 inch of parallel.
4. Pitch: 3 inches plus or minus 1/4 inch. All helix plates shall have uniform pitch.
5. Edge Profile: Circular edge.
6. Spacing: Between 2.4 and 3.6 times helix diameter.

G. Bolts: SAE J429, Grade 8, bolts with nut.

H. Couplings: Integral to shaft.

I. Anchor Plates or Pile Caps: Load-transfer assembly welded from structural steel complying with ASTM A36/A36M.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect structures near the work and underground utilities from damage.

B. Locate the starting point of installation in relation to existing site elevation.

3.02 INSTALLATION

A. Install helical foundations as shown on drawings and approved design documentation. In event of conflict between drawings and approved anchorage design documentation, do not begin construction on any affected items until such conflict has been resolved.

B. Comply with manufacturer's written installation requirements and recommendations for specific project site and conditions.

C. Use installation methods that will not cause damage to existing adjacent or nearby structures.

D. Keep and submit a log of helical foundation installations, including the following data:
1. Date and time of installation.
2. Location of foundation element.
3. Installed foundation type and configuration.
4. Foundation reveal.
5. Total length of installed foundation element.
6. Installed inclination of foundation element.
7. For compression piles, installation torque measurements taken in one to three foot increments of total length.
8. Actual effective torsional resistance.
9. Calculated geotechnical capacity based on actual torsional resistance and soil parameters appropriate for subsurface conditions within three helix diameters above helix depth.
10. Comments pertaining to interruptions, obstructions, or other relevant information.

E. If required, position inclined helical anchors perpendicular in order to assist in advancement into soil before establishing required batter angle; after initial penetration, establish required angle of inclination

F. Engage helical sections into soil and advance in a smooth, continuous manner at a rate of rotation of 5 to 25 RPM.

G. Apply sufficient down pressure to uniformly advance helical sections a distance per revolution approximately equal to pitch of helix plates.

H. Adjust rate of rotation and magnitude of down pressure for specific soil conditions and depths.

I. Provide extension sections as required to achieve required results.

J. Achieve both minimum embedment length and minimum effective torsional resistance prior to terminating foundation installation.

K. Location Tolerances:
   1. Pile Head Horizontal Tolerance: Within 3 inches of location shown on drawings.
   2. Pile Shaft Angular Tolerance: Within 2 degrees of inclination angle shown on drawings.
   3. Anchor Head Location Tolerance: Within 3 inches laterally and 3 inches longitudinally of location shown on drawings.
   4. Anchor Shaft Angular Tolerance: Within 2 degrees of inclination angle shown on drawings.

3.03 ACHIEVEMENT OF EFFECTIVE INSTALLATIONS

A. In the event that the initial installation of a foundation element does not achieve both minimum embedment length and minimum effective torsional resistance, adjust, repair, or replace that foundation element so that it does achieve both requirements.
   1. The following procedures are considered acceptable and do not require prior approval unless otherwise indicated.
   2. All other proposed remedies must be approved by Owner prior to implementation.

B. Minimum Embedment Length Achieved Before Achieving Minimum Effective Torsional Resistance: Use one of the following procedures:
   1. Continue installation to greater depths until minimum effective torsional resistance is achieved, provided that, if maximum length constraint is applicable, continued installation does not exceed said maximum length.
   2. Demonstrate acceptable foundation performance through testing.
   3. Replace foundation with one having a different helix configuration, as follows:
      a. Embed replacement to a length placing last helix at least three times its own diameter beyond position of first helix of replaced foundation.
      b. Achieve minimum effective torsional resistance.
      c. Do not exceed any applicable maximum embedment length.
      d. Test replacement.

C. Allowable Torque Rating Reached Before Achieving Minimum Embedment Length: Use one of the following procedures:
   1. If permitted by Owner, terminate installation at length achieved.
   2. Replace foundation with one having either a higher torsional strength rating or a different helix configuration, as follows:
      a. Achieve minimum embedment length and minimum effective torsional resistance.
      b. Embed replacement to length that places last helix at least three times helix diameter beyond position of first helix of replaced foundation.
      c. Do not exceed any applicable maximum embedment length limit.
   3. If allowed by location tolerance or approved by Owner, remove foundation section and reinstall as follows:
      a. Position reinstalled foundation at least three times diameter of largest helix away from initial location.
      b. Achieve original embedment length and torsional resistance criteria.
      c. If repositioning requires installation of additional helical foundations, adjust nominal loads for spacing changes.

D. Maximum Embedment Length Reached Before Achieving Minimum Effective Torsional Resistance: Use one of the following procedures:
   1. If allowed by location tolerance or approved by Owner, remove and reinstall foundation as follows:
      a. Position reinstalled foundation at least three times diameter of largest helix away from initial location.
      b. Achieve original minimum embedment length and minimum effective torsional resistance.

c. If repositioning requires installation of additional helical foundations, adjust nominal loads for spacing changes.

2. Demonstrate acceptable foundation performance through testing.
3. De-rate load capacity of helical foundation and install additional foundations as necessary; de-rated capacity and additional foundation location shall be subject to approval of Owner.
4. Replace foundation with one having a different helix configuration; achieve minimum embedment length and minimum effective torsional resistance.

E. Failure of Field Quality Control Test: Use one of the following procedures:
1. Install foundation to a greater depth and installation torque and re-test provided that, if a maximum embedment length constraint is applicable, continued installation will not exceed said maximum length constraint.
2. Replace foundation with one having a different helix configuration. Embed last helix at least three times its own diameter beyond position of first helix of replaced foundation without exceeding any applicable maximum embedment length requirements. Re-test replacement.
3. If approved by Owner, de-rate load capacity of helical foundation and install additional foundations at positions that are at least three times diameter of largest helix away from any other foundation locations; space anchors in cohesive soils not closer than four helix diameters.

3.04 FIELD QUALITY CONTROL

A. Cooperate with testing agency and provide full access to installed foundations.

B. Test installed helical foundations indicated per ASTM D1143/D1143M

C. Failure of Tests: Replace or re-drive, and re-test, helical foundations that any fail test and cannot be remedied using any of the procedures described above in "ACHIEVEMENT OF EFFECTIVE INSTALLATIONS" article.

END OF SECTION

SECTION 31 10 00

SITE CLEARING

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the necessary clearing and grubbing of vegetation, shrubs, grasses, stumps, roots, trees, or other objects within the Project area.

1.2 CLEARING AND GRUBBING

A. All areas within the construction limits shall be cleared of any and all surface objects such as but not necessarily limited to trees, stumps, roots, grasses, shrubs, vegetation, or other objectionable obstructions resting on or protruding through the existing ground surface except for those designated to be retained or relocated.

   i. Damage to natural terrain, areas of vegetation, trees, shrubs, etc. outside of the designated clearing limits or limits established in the field during construction shall be repaired, replaced, or otherwise compensated for, as determined by the Owner's Representative, solely at the Contractors expense.
   ii. Any trees, shrubs, vegetation, or other landscape areas within the project area but designated to be retained shall be protected by any and all means necessary by the Contractor. Repair, replacement, or compensation for such shall be as determined by the Owner's Representative, solely at the Contractor's expense.

B. All areas within the grading limits shall be grubbed of all objectionable matter on or projecting thru to the existing ground surface.

   i. All areas of proposed embankment fill shall be grubbed to a minimum depth of six (6) inches or as indicated otherwise within Section 31 2000, Earth Moving.

1.3 LIMITS OF CLEARING AND GRUBBING

A. The limits of clearing and grubbing shall be to the grading limits as shown on the cross-sections, grade elevations, and / or to the new contours as indicated on the construction plans, to a line or location as specifically indicated on such construction plans, or that necessary for completion of the project.

B. Clear and grub a minimum of five (5) feet beyond all building lines, pavement lines, behind curbs, sidewalks, or other finished surfaces. In areas of utilities, clearing and grubbing limits shall be determined by the area necessary to complete the utility installations unless specifically indicated otherwise on the construction plans.

C. All cut or scarred surfaces of trees or shrubs shall be treated with an asphaltic base paint especially prepared for tree surgery, or as further directed by the Owner's Representative. Any broken limbs shall be pruned as directed by the Owner's Representative and treated likewise. Any costs associated with such remediation or replacement of such damaged trees, as determined by the Owner, shall be the responsibility of the Contractor.

D. In no situation shall clearing and grubbing operations extend beyond property and / or easement lines of the Owner unless the Contractor obtains authorization from the adjoining owner(s). The Owner shall not be responsible for communications with such adjacent owner(s), nor any costs associated with damages to such property. The Contractor shall be solely responsible for all such remediation work on

adjoining property(s) and shall be liable for any and all resulting damages, costs, etc.

E. The Contractor shall not enter upon private property for any purpose without first obtaining permission from its Owner. The Contractor shall be solely responsible for the preservation of and shall use every precaution necessary to prevent damage to all trees, shrubbery, fences, culverts, bridges, pavement, driveways, sidewalks, etc., and to all water, sewer, gas, telephone, and electric lines thereof, and to all other public or private property along or adjacent to the work.

1.4 MATERIAL DISPOSAL

A. Unless specifically designated otherwise in the Contract Documents, the Contractor shall reserve the right to profit of any timber harvested as part of the clearing and grubbing operations of this project.

B. All material removed from the project shall be disposed of off-site at a location of the contractor's discretion. Disposal shall follow any and all local, State, or Federal requirements.

C. No dumping material on adjacent property(s) or burial of such material shall be allowed.

D. Burning of perishable debris or material on-site will not be allowed unless written consent is provided by the Owner. If written consent for such burning is provided by the Owner, the contractor shall still remain responsible and liable for all pollution and environmental control of such burning activities.

1.5 QUALITY ASSURANCE / CONTROL

A. Comply with any and all governing State, Local, Federal notification regulations or requirements prior to beginning any clearing and grubbing. Hauling and disposal regulations of authorities having jurisdiction shall also be followed.

1.6 PROJECT CONDITIONS

A. Clearing and grubbing operations schedule shall not interfere with the day to day use of the site or the surrounding areas by the Owner. All elements associated with such work shall be performed in such a manner to not disturb on-going activities of the Owner.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 EXISTING CONDITIONS

A. Contractor shall be responsible for verifying all utilities have been property located in areas of required clearing and grubbing.

B. Contractor shall conduct field observations and document the condition of items designated to be retained.

3.2 PREPARATION FOR CLEARING AND GRUBBING ACTIVITIES

A. Conduct clearing and grubbing operations and remove debris to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by governing regulations.

B. Clearing and grubbing operations shall be conducted in such a manner to prevent injury to pedestrians along with damage to adjacent buildings, streets, utilities, and facilities to remain. A safe and protected passage for pedestrians around the project area(s) shall be provided by the contractor. As a minimum, the following shall be provided:

   i. Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways where required by authorities having jurisdiction.

   ii. Protect existing site improvements, appurtenances, and landscaping to remain.

   iii. Erect a plainly visible fence around drip line of individual trees or around perimeter drip line of groups of trees to remain.

C. Pollution Controls: Water mist, temporary enclosures or covers, or any other means, methods, techniques to limit the spread of dust, dirt, or debris shall be the responsibility of the Contractor.

   i. Hazardous conditions such as ice, flooding, and pollution when using water shall be avoided or mitigated.

   ii. Remove and haul debris in such a manner that spillage onto existing surfaces shall be prevented.

   iii. Any dust, debris, dirt, etc. caused by the clearing and grubbing process on existing buildings, streets, structures, vehicles, etc. shall be immediately cleaned by any and all means necessary as directed by the Owner at the sole expense of the Contractor.

END OF SECTION 311000

SECTION 31 20 00
EARTH MOVING

PART 1 – GENERAL

1.1 GENERAL

A. This section includes the necessary topsoil stripping, borrow excavation, unclassified excavation, unclassified excavation, unsuitable / unconsolidated materials excavation, preparation of subgrade, and other earthwork related scope items associated with the Project.

B. All soils shall be classified using the Unified Soil Classification System unless indicated otherwise within the Geotechnical Report.

C. The Contractor is solely responsible for the means, methods, techniques, and sequences required to perform the excavation, site grading, and backfill operations required to complete the work. No portion of the Contract Documents shall be interpreted as limiting either the extent of excavation required or the equipment required to affect the work.

D. The Contractor shall be fully responsible for the disposal of all excess materials resulting from earthwork operations at no additional cost to the Owner.

E. The Contractor shall be fully responsible for the location, construction, maintenance, and removal of all haul roads.

F. Specifications for excavation and embankment shall follow the latest edition of the Alabama Department of Transportation Standard Specifications for Highway Construction unless specified otherwise herein.

G. The Contractor shall be responsible for the prevention of erosion, runoff control, and the protection of existing streams. Hay bales, silt fencing, and sheeting exposed areas shall be utilized to minimize sediment transport from cut areas, temporary spoil piles, and other exposed areas.

H. Where excavations are made adjacent to existing buildings, other structures, utilities, or in paved streets or alleys, the Contractor shall take particular care to sheet, shore, and brace the sides of the excavation adequately so as to prevent any undermining of or settlement beneath such structures, utilities or pavements. Where necessary, the Contractor shall be responsible for underpinning or bracing existing structures, utilities or pavement to prevent settlement or other damage. Where necessary, the Contractor shall be responsible for temporarily relocating existing utilities. All such relocations shall be coordinated with the Owner of the utility.

I. Sheeting, shoring, and bracing materials shall not be left in place unless shown in the contract documents or approved by the Owner's Representative. Such materials shall be removed in such manner as to protect the work, workmen, the Owner's facilities, adjacent property and the general public.

J. The Contractor shall take all due precautions for the safety of the work, the workmen, the Owner's facilities, the general public, adjacent utilities and structures.

    a. Excavated surfaces too steep to be safe and stable if unsupported shall be supported as necessary to safeguard the work and workmen, to prevent sliding or settling of the adjacent ground, and to avoid damaging existing improvements. The width of the excavation shall be increased if necessary to provide space for sheeting, bracing, shoring, and other supporting installations. The Contractor shall furnish, place and subsequently remove such supporting installations.

K. The Contractor shall comply with federal, state, and local ordinances, laws, guidelines and regulations related to earthwork and excavation.

L. In all cases, where materials are deposited around open excavations, they shall be placed so that, in the event of rain, no damage will result to the work or adjacent property.

1.2 RELATED SECTIONS AND DOCUMENTS

A. Drawings and general provisions of the Contract Documents including General, Supplemental, and Special Conditions, and Division 01 Specification Sections, apply to this Section.

B. Geotechnical Report.

1.3 SUBMITTALS

A. Laboratory test data for all types of embankment fill material indicating the following shall be provided by the Contractor:

i. Borrow pit location.

ii. Minimum Standard Proctor Density (ASTM D 698).

iii. Optimum Moisture Content.

iv. Liquid Limit and Plasticity Index.

1.4 QUALITY CONTROL / QUALITY ASSURANCE / TESTING

A. The Owner will secure a geotechnical services entity for all soil testing to perform in-place density testing. All initial soil testing shall be paid for by the Owner. When test(s) fail to meet the project specifications, any subsequent testing and associated scope shall be the responsibility of the Contractor.

i. The location of density tests shall be as determined in the field by the Owner's Representative.

ii. The frequency of testing shall be as indicated within the Geotechnical Report or as determined in the field by the Owner's Representative based on field conditions.

B. The acceptance of any subgrade areas shall be determined by the Owner and / or their representatives.

C. The Contractor shall be responsible for providing all means, methods, techniques, sequences, labor, equipment, material, etc. necessary to provide excavations and fill embankments that follows the Contract Documents, properly drains, and is smooth and uniform. Final subgrade elevations shall be within reasonably close proximity to the design elevations specified in the contract documents. In areas to receive pavements or buildings, the final subgrade elevations shall be within ±1" of the specified elevation. In all other areas, the final subgrade elevations shall be within ± 2" of the specified elevation.

1.5 DEFINITIONS

A. Unclassified Excavation

i. Excavation of any and all material that can be excavated, transported, and unloaded by the use of heavy ripping equipment and wheel type tractor scrapers with or without push tractors, or that can be excavated and dumped in place, or loaded onto hauling equipment by means of excavators having a rated capacity of one (1) cubic yard and equipped with necessary attachments (shovel, bucket, backhoe, dragline, clam shell, rock teeth, etc.) appropriate for the type of materials and site conditions. The presence of isolated boulders, clumps, or fragments of rock greater than the one (1) cubic yard size will not in itself be cause to change the classification of such excavation material.

ii. Unclassified excavation shall consist of excavation of all on-site materials encountered on the project, excluding unsuitable or rock materials when such items are included as separate pay item(s) or allowances in the Contract Documents. If no such separate pay item(s) or allowances are included, all such material shall be treated as unclassified excavation.

iii. Unless noted otherwise within the Construction Documents, cuts in soil within areas of any future or proposed buildings, streets, parking, hardscape areas shall be excavated a minimum of one (1) foot below the proposed subgrade in order to identify and address any soft or yielding soil areas. Such excavation and subsequent backfill shall be considered as unclassified excavation.

iv. All suitable on-site excavation may be excavated, processed, and used as embankment fill on the project. Materials not suitable for use as embankment fill shall be, but not necessarily limited to, organic silts, organic clays of medium to high plasticity, inorganic and elastic silts, inorganic clays with high plasticity index, peat, or other materials as identified within the Geotechnical Report.

v. Existing concrete, asphalt, or gravel surfaces, or rock excavation materials may be used as unclassified excavation. Such material shall be stripped, cleaned of any unsuitable materials, any steel reinforcement removed from concrete, and broken down by roadway / pit operations or crushing methods to allow approximately 100 percent passing the 3" sieve. Such material shall not be used within eighteen (18) inches of the subgrade, improved roadbeds, footings, slabs, or utilities.

vi. All material used as fill shall meet the soil classification, liquid limit, and plasticity index requirements as indicated within the Geotechnical Report.

B. Off-Site Borrow Excavation for Embankment Fill

i. Embankment fill materials above water and below subgrade shall be of any material stable which can be compacted to the specified project density requirements, unless specified otherwise in the Contract Documents. Materials unsuitable for use as embankment fill shall be as indicted in Part 1, 5.B.iii.

ii. All material used as embankment fill shall meet the soil classification, liquid limit, and plasticity index requirements as indicated within the Geotechnical Report.

iii. Existing concrete, asphalt, or gravel surfaces per Part 1, 5.B.iv may be used as embankment fill.

iv. All embankment fill materials shall be free of any unsuitable materials, including but not necessarily limited to leaves, grasses, roots, wood materials, etc.

C. Off-Site Borrow for Improved Roadbeds or Subgrades

i. Improved roadbed or subgrade materials shall be any stable material meeting the requirements of soil classified as A-4 or better which can be compacted to the specified project density requirements, unless specified otherwise in the Contract Documents.

ii. All material used as improved roadbed or subgrade materials shall meet the soil classification, liquid limit, and plasticity index requirements as indicated within the Geotechnical Report.

iii. All improved roadbed or subgrade materials shall be free of any unsuitable materials, including but not necessarily limited to leaves, grasses, roots, wood materials, etc.

D. Unsuitable Material

i. Materials as indicated within the Geotechnical report, not meeting the requirements for use as fill or topsoil, or as identified during field operations by the Owner's Geotechnical Representative as being unsuitable for use as fill within the project area.

ii. Only materials identified and quantified in the field by the Owner's Geotechnical Representative shall be classified as unsuitable materials. The Owner's Geotechnical Representative shall be notified immediately of any suspect materials so a proper determination may be made. Removal of any such material prior to the determination and approval of the Owner's Representative shall not be classified as unsuitable materials. Any such material excavation and subsequent fill placement shall be at the Contractor's expense.

iii. Earthen materials meeting all of the project requirements as suitable fill, excluding liquid limits, shall not be classified as unsuitable materials due to the in-place moisture content of such material. Such material shall be processed by all means, methods, techniques, and sequences in order to bring the moisture content within the liquid limit requirements for the project at no additional cost to the Owner. Likewise, any materials lacking the liquid limits requirement on the project due to the Contractor's negligence of properly maintaining or draining the areas shall not be deemed as unsuitable materials.

E. Unconsolidated Materials

i. Materials being deemed as usable for embankment fill based on the soil characteristics but as identified during field operations by the Owner's Geotechnical Representative as being unconsolidated soil within the project area. Such material may be processed and used as fill when properly consolidated. Unconsolidated materials shall be considered unclassified excavation.

ii. Only materials identified and quantified in the field by the Owner's Geotechnical Representative shall be classified as unconsolidated materials. The Owner's Geotechnical Representative shall be notified immediately of any suspect materials so a proper determination may be made. Removal of any such material prior to the determination and approval of the Owner's Representative shall not be classified as unconsolidated materials. Any such material excavation and subsequent fill placement shall be at the Contractor's expense.

F. Rock Excavation

i. Excavation of all hard, compacted, cemented, or rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material one (1) cubic yard or more in volume that exceeds a standard penetration resistance of 100 blows / 2 inches as tested by the Owner's Geotechnical Representative. Rock material may be processed and re-used as embankment fill on the project as referenced under Unclassified Excavation.

ii. Rock excavation shall extend to a minimum of twelve (12") below the finished subgrade.

iii. Unless approved otherwise by written consent from the Owner, no blasting shall be permitted. All rock excavation shall be performed with the use of heavy machinery such as but not limited to ripper attachments to bulldozers, excavator with rock bucket, hydraulic hammering, or drilling.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 STABILITY

A. The stability of the subgrade after reaching planned grade in cut areas, areas of unsuitable and/or unconsolidated materials, and before fill placement shall be assessed and / or evaluated under the direction and observation of the Owner and the Owner's Geotechnical Representative. Areas that exhibit soft or yielding characteristics shall be treated as recommended by the Owner and the Owner's Geotechnical Representative. The Owner and the Owner's geotechnical representative shall be present to direct any and all subgrade suitability evaluations and operations on the project.

3.2 FILL PLACEMENT

A. Areas of fill shall be as indicated on the grading plan(s) of the Contract Documents.

B. Sloped surfaces steeper than 1:4 (horizontal : vertical) shall be broken up, plowed, stepped, or benched as directed by the Owner's Representative so that the fill material will sufficiently mend with the existing earthen material.

C. All areas to receive fill shall be scarified to a minimum depth of six (6) inches and compacted prior to the placement of any fill material.

D. No fill material shall be placed on muddy, wet, frozen, or frosted surfaces.

E. Material shall be moistened or aerated as necessary to provide the required moisture content.

F. Satisfactory material shall be placed and compacted in maximum loose lifts of eight (8) inches in depth.

G. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel wheeled rollers or other equipment well suited to the soil being compacted.

H. If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than six (6) inches and recompacted before the next layer is placed.

I. The top surfaces of embankments shall be maintained approximately level during construction, except that a crown or cross-slope of not less than 2 percent shall be maintained to ensure effective drainage, and except as otherwise specified for drain fill zones. If the drawings or specifications require that fill be placed at a higher level in one part of an embankment than another, the top surface of each part shall be maintained as specified above.

J. Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the specifications shall be reworked to meet the requirements or be removed and replaced by acceptable fill, all at the Contractor's expense.

K. Compaction requirements for fill shall be as determined by ASTM D 698 at a minimum Standard Proctor Density of 98%, with a moisture content of ± 3% of optimum. Wetting, drying, processing, or other manipulations of the material by any means, methods, or techniques in order to achieve a uniform and acceptable moisture content throughout the layer will be required.

L. No trash, debris, etc. shall be within any fill areas.

M. For backfill around structures, walls, foundations, or other hardscape:

   i. Proper curing time (minimum of 85% of concrete design strength) shall be obtained prior to placement of any earthen backfill around cast-in-place concrete in order to withstand backfilling operations. Any damage to structures, curbs, sidewalks, etc. due to backfill operations prior to such concrete reaching the full compressive strength shall be removed and replaced by the Contractor as directed by the Owner's Representative at no cost to the Owner.

   ii. Unless indicated otherwise, select earthen fill shall be used for backfill around structures, walls, foundations, or other hardscape items.

iii. The backfill shall be compacted by any and all means necessary in loose lifts no greater than six (6) inches in depth in such a manner to avoid any settlement around such structure.

3.3 STRIPPING OPERATIONS

A. All areas receiving fill shall be stripped of topsoil, debris, leaves, trees, roots, concrete, pavement, or any other objectionable materials to a depth necessary to remove such items prior to fill placement.

B. Unless indicated otherwise in the Contract Documents, the limits of striping shall be as follows:

i. Five (5) feet outside the edge of pavement, curbs, or sidewalks, the greater of the three, along roadways, parking lots or other paved areas.

ii. Five (5) feet beyond the exterior face of buildings.

iii. Two (2) feet beyond the limits of areas of excavation.

C. If adequate space is available on-site and if approved by the Owner, on-site stockpiling of topsoil material shall be acceptable. Otherwise, any such material shall be immediately removed from the project area.

i. If stockpiled on-site, the Contractor shall be responsible for properly segregating and protecting the topsoil material from migrating with any undesirable materials prior to re-use.

ii. The Contractor shall be responsible for any temporary erosion control necessary at any of the stockpile areas, including but not necessarily limited to proper compaction and shaping of the stockpile(s), covering with plastic for moisture protection, temporary grassing / mulching, or other erosion control BMP's.

3.4 SUBGRADE PREPARATION (outside of landscape areas – see Section 32 2945, Topsoil and Subgrade Preparation, for areas within landscape)

A. Sub-grade shall be free from any standing water and within the allowable moisture limits, as determined by the Owner's Representative, prior to placement of any fill material.

B. All temporary stone for roadways, construction accesses, sidewalks, drives, etc. shall be completely removed at the end of the project. It is the Contractor's sole responsibility to fully remove these temporary materials as the project is completed. This applies to all materials, equipment, etc. the Contractor transports to the project site. There shall be no wasting of stone on-site by any contractor, subcontractor, etc. on the Project site. The Contractor is ultimately responsible for any and all stone and related clean-up on the Project site.

C. All prepared subgrades shall be 80% stone free. Subgrade that contains more than 20% in any 12" x 12" area shall be removed and replaced by the Contractor at no additional expense to the Owner.

D. The Contractor shall install all underground utilities and sleeves prior to base installation. If base is installed, compacted, tested, etc., and utilities are later installed, then the base shall be considered contaminated and shall be removed/reinstalled, recompacted, and retested at the Contractor's expense. Final base is not considered temporary stone. Therefore, contamination shall not be allowed. Contaminated base shall be removed and replaced as directed by the Owner's Representative at the Contractor's expense.

E. When proof-rolling is required by the Owner's Representative, it shall be proof-rolled at a minimum with a fully loaded, triaxle dump truck in the locations, directions, configurations, methods as determined in the field by the Owner's Representative.

END OF SECTION 312000

SECTION 31 21 00

TRENCHING, BACKFILL, AND COMPACTION OF UTILITY TRENCHES

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the necessary requirements associated with trenching, backfill, and compaction for utilities such as but not limited to water mains, sanitary sewer mains, storm sewers, gas mains, sanitary force mains, etc. placed beneath pavement, hardscape, and improved or unimproved lawn areas.

B. The Contractor is solely responsible for the means, methods, techniques, and sequences required to perform the trench excavation, backfill, and compaction operations to complete the work. No portion of the Contract Documents shall be interpreted as limiting either the extent of such work required or the equipment required to affect the work.

C. The Contractor shall be fully responsible for the disposal of all excess materials resulting from trenching and backfill operations at no additional cost to the Owner.

D. The Contractor shall be fully responsible for location, construction, maintenance, and removal of all haul roads.

E. The Contractor shall be responsible for the prevention of erosion, runoff control, and for the protection of surrounding, adjacent, and existing streams, sewer systems, and / or drainage ways. Hay bales, silt fencing, and sheeting, or any other means, methods, techniques shall be utilized to minimize sediment transport from all exposed areas. Any areas damaged or impacted as a result of erosion / sedimentation run-off shall be immediately repaired to a condition equal to or better than as before construction as determined by the Owner's Representative at no additional cost to the Owner.

F. Where trench excavations are made adjacent to existing buildings, other structures, utilities, or in paved streets or alleys, the Contractor shall take particular care to sheet, shore, and brace the sides of the excavation adequately so as to prevent any undermining of or settlement beneath such structures, utilities or pavements. Where necessary, the Contractor shall be responsible for underpinning or bracing existing structures, utilities or pavement to prevent settlement or other damage. Where necessary, the Contractor shall be responsible for temporarily relocating existing utilities. All such relocations shall be coordinated with the Owner of the utility.

   i. Sheeting, shoring, and bracing materials shall not be left in place unless shown in the contract documents or approved by the Owner's Representative. Such materials shall be removed in such manner as to protect the work, workmen, the Owner's facilities, adjacent property and the general public.

G. The Contractor shall take all due precautions for the safety of the work, the workmen, the Owner's facilities, the general public, adjacent utilities and structures.

   i. Excavated surfaces too steep to be safe and stable if unsupported shall be supported as necessary to safeguard the work and workmen, to prevent sliding or settling of the adjacent ground, and to avoid damaging existing improvements. The width of the excavation shall be increased if necessary, to provide space for sheeting, bracing, shoring, and other supporting installations. The Contractor shall furnish, place and subsequently remove such supporting installations.

H. The Contractor shall comply with federal, state, and local ordinances, laws, guidelines and regulations related to excavation.

I. In all cases where materials are deposited around open trench excavations, they shall be placed so that in the event of rain, no damage will result to the work or adjacent property. All drainage ways, gutters, streams, etc. shall be maintained at all times. The Contractor, at no additional expense to the Owner, shall remove any and all eroded or washed material, debris, etc. that enters pipes, ditches, or streams as a result of the work on the project and as determined by the Owner's Representative.

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Ductile Iron Pipe and Fittings

B. PVC Pipe and Fittings

C. High Density Polyethylene Pipe and Fittings

D. Reinforced Concrete Pipe

E. Valves, Valve Boxes, and Vaults

F. Fire Hydrants

G. Storm and Sanitary Sewer Structures

1.3 REFERENCES

A. U.S. Department of Labor, Occupational Safety and Health Administration.

B. Alabama Department of Transportation Standard Specifications for Highway Construction, latest edition.

1.4 RELATED SECTIONS AND DOCUMENTS

A. Drawings and general provisions of the Contract Documents including General, Supplemental, and Special Conditions, and Division 01 Specification Sections, apply to this Section.

B. Geotechnical Report.

1.5 QUALITY CONTROL / QUALITY ASSURANCE / TESTING

A. The Owner will secure a geotechnical services entity for all soil testing to perform in-place density testing, and also gradation analysis for any type of crushed stone materials used if requested by the Owner or the Owner's Representative. All initial soil density testing shall be paid for by the Owner. When such test(s) fail to meet the project specifications, any subsequent testing and associated scope shall be the responsibility of the Contractor.

   i. The location of the soil density test(s) shall be as determined in the field by the Owner's Representative.

   ii. The frequency of the soil density testing shall be as indicated within the Geotechnical Report or as determined in the field by the Owner's Representative based on field conditions.

B. The Contractor shall be responsible for providing all means, methods, techniques, sequences, labor, equipment, material, etc. necessary for trench excavations, backfill, and compaction that follows the Contract Documents.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Select Backfill, crushed aggregate

i. Crushed stone select backfill, where specified or required, shall be crushed limestone. Crushed stone shall meet or exceed the requirements of the Alabama Department of Transportation Standard Specifications for Highway Construction, Section 801, No. 57 or 825 Type 'B' Stone as indicated on the construction plan details.

a. Any use of ALDOT No. 57 or similar gradation of crushed stone shall require such backfill material to be completely wrapped with a filter fabric.

B. Select Backfill, sand

i. Sand select backfill, where specified or required, shall be a local pit-run sand suitable for the purpose intended, generally consisting of hard, sound material, predominantly quartz or other hard durable, rock, including friable, loosely bound deposits of sandstone conglomerate. The sand shall be free from a coating of injurious material, lumps of clay, loam, organic matter, or other foreign material.

a. Any use of sand shall require such backfill material to be completely wrapped with a filter fabric.

C. Standard Backfill:

i. Standard backfill shall consist of native soils free of large rocks, boulders and other deleterious substances. The Contractor may elect to utilize crushed stone select backfill instead of standard native backfill material at their discretion. If so, such select backfill material type shall be as approved by the Owner and be at the sole expense of the Contractor.

D. Bedding

i. Class '1' Bedding shall confirm to Alabama Department of Transportation Standard Specifications for Highway Construction, Section 801 as follows, unless indicated otherwise on the construction plans:

a. Gravity pipe (all material types).....ALDOT No. 57 crushed limestone

b. Non-gravity pipe (plastic material type).....ALDOT 8910 crushed limestone

c. Non-gravity pipe (metallic material type).....ALDOT No. 57 crushed limestone

ii. Class '2' Bedding shall be reinforced concrete (3000 psi 28-day compressive strength).

iii. Class '3' Bedding shall be native soil, confirming to the above specifications for Standard Backfill. Such bedding with native backfill shall be placed in uniform thicknesses and be compacted in place so as to eliminate any potential for settlement around the pipe or of the trench above. Native bedding shall be on a uniform base following the required grade of the associated pipe.

iv. Class '4' Bedding shall be sand confirming to the above specifications for Select Backfill, sand.

E. Trench Foundation

i. Trench foundation material shall be Alabama Department of Transportation Standard Specifications

for Highway Construction, Section 801, No. 57 crushed limestone, unless a different gradation is otherwise directed by the Owner's Representative.

ii. Trench foundation material shall only be used when approved in advance by the Owner's Representative.

F. Filter Fabric – Filter fabric required in areas of Select Backfill and / or Bedding (No. 57 crushed stone or sand) shall be Terratex No. 4 or approved equal.

PART 3 – EXECUTION

3.1 EXAMINATION OF EXISTING CONDITIONS / PROTECTION, REMOVALS, REPLACEMENTS

A. Existing Underground Utilities:

a. The Contractor shall protect all existing utilities during the trenching operation. The Contractor shall cooperate fully with the utility owner's request(s) for temporary and permanent supports during the trenching operation and shall furnish and install supports at no additional cost to the Owner. The Contractor shall be held liable for damage, including negligent or willful damage to any other utility and shall pay for the cost of all necessary repairs and any resulting damages.

b. Storm sewers in conflict with the proposed trench may be carefully dislodged and stockpiled. The pipes shall be cleaned and replaced immediately after new construction is clear. Storm sewers damaged by the Contractor shall be replaced with new pipe at no additional cost to the Owner. All storm sewers removed shall be re-laid to proper grade on bedding and backfilled according to the above specifications for such bedding and backfill so that settlement will not occur.

c. Sanitary sewer mains in conflict with the proposed trench may be carefully dislodged and stockpiled, but only if suitable by-pass pumping or other approved means for handling the sewage has been installed in order to keep the sanitary sewer service intact. If the sewer mains are left in place, the Contractor shall take whatever means necessary to support sewer mains to their true line and grade when they are encountered during excavation. The pipe shall be supported so that no leakage will occur. If a repair becomes necessary the contractor shall use materials of the same type and class of pipe as the existing if available. At a minimum, PVC pipe and fittings shall conform to ASTM D3034, SDR 26. All couplings to existing pipe shall be manufactured couplings and all metal parts shall be stainless steel. Under no circumstances shall sewage be allowed to discharge into open trenches, storm sewers, or the ground surface. Sanitary sewers damaged by the Contractor shall be replaced with new pipe at no additional cost to the Owner. All storm sewers removed shall be re-laid to proper grade on bedding and backfilled according to the above specifications for such bedding and backfill so that settlement will not occur.

B. All streets, roads, alleys, etc. shall be accessible by emergency response vehicles at all times.

i. If private driveways are disrupted, access to the associated residence(s) or place of business shall be provided by the Contractor. The Contractor shall be responsible for communicating with such property owners prior to any disruptions to the driveways.

ii. Any closure of existing pedestrian paths, sidewalks, etc. shall require proper signage in advance of such closure, and also adequate detour(s) / direction(s) to the nearest path for continuation of such pedestrian movement(s).

C. Ornamental Shrubs and Trees

i. Ornamental shrubs and trees shall not be removed unless directed by the Owner's Representative.

When ornamental shrubs and/or trees are to be removed and replaced, the following steps shall be followed:

a. Remove all trees, shrubs or plants, which interfere with construction intact with root system and protect from drying during construction period.

b. Replace plant to original location as soon as possible, taking care to ensure that hole is large enough, and no damage is done to root system.

c. Fill hole with good topsoil and tamp firmly into place.

d. Water plant(s) as necessary for reestablishment.

ii. The Contractor shall confine his operations to the construction limits, rights-of-way, and/or easements designated. The Contractor shall be responsible for all repair or replacement of any damage to adjacent property at no additional cost to the Owner.

D. Existing Fencing

i. All fences in conflict with the proposed construction shall be removed in a neat and workmanlike manner and then replaced immediately following construction operations. Where materials removed are not suitable for reuse, they shall be replaced with new material of equal or better quality and construction. All fences shall be rebuilt to line, with posts well set, wires fastened with new staples or ties and well stretched. All corner and end posts shall be well braced and set a minimum of 30 inches in the ground.

E. Existing Utility Poles, Guy Wires, Etc.

i. All utility poles, guy wires, signposts, signs, and similar private or public obstructions which are indicated on the plans or not but existing on the ground shall be removed and replaced by the Contractor at his own expense. In the event any such items are damaged or destroyed by the Contractor's operations, they shall be replaced by the Contractor at the Contractor's expense.

ii. When it is necessary to remove, adjust, brace, support, stabilize any existing utility poles, guy wires, etc., representatives of the utilities involved shall be notified to decide the method and nature of work to be done. The Contractor shall make satisfactory arrangements with such utility owners for the required scope. Any such work shall be at the Contractor's expense, unless otherwise specifically indicated otherwise by the Contract Documents.

3.2 TRENCH PREPARATION

A. Clearing and Grubbing.

i. Unless stated otherwise, clearing and grubbing operations shall follow all the requirements of Section 31 1000.

ii. In no situation shall any clearing and grubbing materials be buried in the trenches on the project.

iii. On public property, existing trees or limbs over 2 inches in diameter shall not be cut unless they are within 7 feet of pipe centerline or specific permission is received from the Owner. On private property, easements, or in lawns, no trees or brush shall be cleared or cut without prior approval of the Owner's representative following communication and coordination with the land owner. The Contractor shall be required to remove trees, shrubs or plants on private property intact, and to ball the roots, keep watered as required, and replant in their original location upon completion of

pipe laying operations, unless written permission is obtained from the Owner's Representative, or unless otherwise specified. The Contractor shall replace, at his own expense, any trees, shrubs, or plants which shall be damaged as a result of project, or which shall die within 1 year of the time it was disturbed or damaged.

B. Existing Utility Verification – refer to Section 02 2102.

C. Saw-Cutting of Existing Pavement, Concrete, Curbs, Sidewalks, Gutters, etc.

i. All existing pavement, concrete, curb, sidewalks, etc. shall be neatly saw-cut in a straight and orderly manner prior to beginning any trench excavation. Saw-cut lines shall be made at the existing joints lines for all concrete, curb, gutters, or sidewalks unless specifically directed otherwise by the Owner's field representative. The location(s) shown on the construction plans shall be used as a general guide to the actual saw-cut locations. Actual saw-cut locations shall be adjusted in the field as required to align with the existing joints.

ii. All appropriate permits, traffic control devices, barricades, cones, etc., shall be in place prior to beginning any saw-cutting activities which will impair vehicular traffic or pedestrian movements. Any necessary cleanup of debris, residue, etc. from the saw-cutting activities where demolition does not immediately follow shall be done as soon as saw-cutting operations are completed.

3.3 TRENCH CONSTRUCTION

A. General:

i. The Contractor is solely responsible for the safety and welfare of all workers, personnel, public, etc. in regard to trench excavations or other work on the project. The Contractor shall take whatever actions, means, methods, techniques, or sequences that are needed to protect workers, staff, general public, the Owner and all of their representatives, etc. in regards to safety on the project. The Contractor shall be responsible for being knowledgeable of and following any and all applicable OSHA guidelines.

ii. Trenching or excavation for pipelines shall consist of the excavation necessary for the installation of sanitary or storm sewers, water lines, gas lines, and other utilities and all appurtenant facilities, including manholes, junction boxes, inlets, outlets, thrust blocks, and pipe protection.

iii. Trench excavation shall be made in an open cut method unless tunneling, boring, or other construction methods are specifically indicated in the construction plans or requested by the Contractor and approved by the Owner's Representative. Trenches shall be true to the lines and grades shown on the plans or established by the Owner's Representative.

iv. When vertical banks for trench excavation are not practical to construct or are unable to provide safe working conditions to workpersons per the most recent OSHA adopted standards, the banks may be sloped provided that such excavation does not damage adjacent structures. However, when trench banks are sloped, such banks shall be cut to vertical planes for that part of the trench up to twelve (12) inches above the top of the pipe.

v. Every drain, gutter, culvert, or sewer for surface drainage encountered is to be kept open for both temporary and permanent flow, or if necessarily closed, other adequate provision for drainage is to be made.

vi. Pipe trenches shall not be excavated more than 300 feet in advance of pipe laying and temporary

bridges or cross walks shall be constructed where required to maintain vehicular or pedestrian traffic.

vii. Trench widths shall be confined to dedicated rights-of-way or construction easements.

viii. Trench widths shall be kept as narrow as possible, adhering to any OSHA requirements, but shall be wide enough to accommodate the necessary mechanical consolidation of all backfill materials.

ix. Where select backfill is specified or required, all excavated materials shall be immediately removed from the project site by the Contractor.

B. Sheeting, Shoring, and Bracing

i. The Contractor shall be responsible for the selection, design, application, implementation, etc. of any and all types sheeting, shoring, and / or bracing necessary for the project.

ii. The sides of all trench excavations shall be sufficiently sheeted, shored, and braced whenever necessary to prevent slides, cave-ins, settlements, or movement of the banks and to maintain the excavation clear of obstructions that will, in any way, hinder or delay the progress of the work.

iii. Wood or steel sheet piling of ample design and type shall be used when necessary.

iv. All sheeting, shoring, and bracing shall have sufficient strength and rigidity to withstand the pressures exerted and to maintain the walls of the excavation properly in place and protect all persons and property from injury or damage.

v. Where excavations are made adjacent to existing buildings or other structures, or in paved streets or alleys, the Contractor shall take particular care to sheet, shore and brace the sides of the excavation adequately so as to prevent any undermining of or settlement beneath such structures or pavement. Underpinning of adjacent structures shall be done when necessary. The Contractor will be liable for any damage to any structure that results from his operations.

vi. Sheeting, shoring or bracing materials shall not be left in place unless so shown by the plans or approved by the Owner. Such materials shall be removed in such manner as will not endanger or damage the new structure or any existing structures or property, either public or private, in the vicinity, and so as to avoid cave-ins or slides. No trench sheeting and bracing shall be removed until the trench has been backfilled at least two (2) feet above the top of the pipe.

C. Rock Excavation

i. Excavation of all hard, compacted, cemented, or rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material one (1) cubic yard or more in volume that exceeds a standard penetration resistance of 100 blows / 2 inches as tested by the Owner's Geotechnical Representative. Rock material may be processed and re-used as embankment fill on the project as referenced under Section 31 2000, Part 1, Paragraph 5.A, Unclassified Excavation.

ii. All rock excavation shall be performed with the use of heavy machinery such as but not limited to ripper attachments to bulldozers, excavator with rock bucket, hydraulic hammering, or drilling. Unless approved otherwise by written consent from the Owner, no blasting shall be permitted. If granted, the Contractor shall be responsible for all aspects, including but not necessarily limited to, pre-blast surveys and observations, methods of blasting, post-blast surveys / observations, any damages associated with such blasting, etc. The Owner or the Owner's Representatives shall not be responsible for any communications, coordination, etc. associated with the blasting. All blasting shall be conducted with

due regard to the safety of persons and property in the vicinity of the work and in strict conformity with all laws, ordinances, or regulations governing blasting and the use of explosives. The Contractor shall be licensed for this type of blasting and shall follow the insurance requirements of the general conditions. The Contractor shall also notify all applicable local emergency response entities (fire, police, etc.) at least 48 hours in advance of any blasting.

iii. Rock encountered in trench excavation for pipelines shall be removed for the over-all width of trench and to a minimum depth of twelve (12)-inches below the bottom of the outside of the pipe, if rock extends to such depths. Where pipelines are constructed on concrete cradles, rock shall be excavated to the bottom of the cradle as shown on the plans. When necessary to provide sufficient working space, rock shall be excavated to additional depth for bell holes.

iv. After the Owner's Representative has observed the completed excavation, the space below the pipe or structure grade shall be filled with an approved foundation material and compacted to the proper grade.

v. Rock excavation near existing structures of all types shall be conducted with the utmost care, and every precaution shall be taken to prevent damage to such structures. Any damage or injury of whatever nature to persons or property caused directly or indirectly by rock excavation methods and operations shall be promptly repaired, replaced, or compensated for by the Contractor at his own expense and to the satisfaction of the persons injured or the property owners.

D. Dewatering

i. All excavated areas shall be kept free of standing water once excavated and prior to trench backfill. The Contractor shall provide all necessary manpower, equipment, tools, machinery, etc., necessary for the removal of water at all times.

ii. Bedding, trench foundation, or select / standard backfill shall not be placed in trenches which have water standing or wet, unstable trenches. Any trench material that cannot be properly dewatered shall be removed and replaced with suitable backfill material as required to provide an adequate trench bottom appropriate for the pipe installations.

iii. All water removed or diverted from the trench excavations shall be disposed of in a manner that does not damage or destroy the adjacent or surrounding property. Under no circumstances shall the water be diverted in a manner that will create flooding of streets, adjacent or surrounding properties, sidewalks, gutters, etc. Diverting of the water through portions of the new pipeline not yet accepted by the Owner shall not be allowable unless approved by the Owner.

E. Trench Foundation

i. Where unsuitable material for supporting pipe bedding is encountered as determined by the Owner's Representative, these materials shall be removed and replaced with trench foundation material. This shall only be done at the direction of the Owner's Representative.

ii. Trench foundation material shall be placed at the specified trench width from the bottom of the excess excavation to the bottom grade line of the pipe bedding.

iii. Trench foundation material so placed shall be as shown on the trench detail drawings or specified herein. If not shown on the drawings, trench foundation material shall consist of Alabama Department of Transportation Standard Specifications for Highway Construction, Section 801, No. 57 crushed

limestone. Depending on the existing conditions, the Owner may direct the use of a different gradation of stone material.

F. Trench Bedding and Backfill

i. All areas where bedding is not specifically called for or required, the pipe shall be bedded on native soils. Bell holes shall be excavated so that the entire pipe length rests on firm soil.

ii. Areas over excavated by the Contractor through negligence or convenience shall be backfilled and tamped with approved materials at the expense of the Contractor per the construction plan trench details or bedding requirements of these specifications.

iii. Backfilling shall not begin before the Owner's Representative has inspected the grade and alignment of the pipe.

iv. Pipe bedding and trench backfill material shall be as per the trench details on the construction plans and as specified herein.

v. If select backfill is not specified or required based on the pipe material type and / or location, backfilling to a point 12-inches above the top of the pipe, defined as the pipe zone, shall be done with good earth, sand or gravel and shall be free from large rocks or hard lumpy materials. Large rocks shall be defined as any larger than 2-inches in diameter. No materials of perishable, spongy or otherwise unsuitable nature shall be used in backfilling. It is essential that the completed backfill be done in such a manner as to minimize voids in the backfill. All utility trenches shall be backfilled as per the construction plan trench details as a minimum.

vi. For backfilling up to twelve (12) inches above the top of the pipe, place trench backfill material at approximately the same rate along both sides of the pipe and mechanically consolidate by tamping in layers not to exceed eight (8) inches of loose fill up to the horizontal centerline of the pipe. The intent is to cradle the pipe so that the full length is uniformly supported on firm bedding and the weight of the pipe and backfill is borne uniformly by the lower half of the pipe barrel. Backfilling and tamping procedures shall be performed in such a manner to ensure that no voids or un-compacted areas occur beneath the bottom haunch of the pipe which could potentially result in trench settlement. The Contractor shall utilize any and all methods necessary to properly compact the haunch area(s) of the pipe and associated trench. The trench width shall be adequately sized so as to allow for proper trench backfill placement and compaction while also providing adequate space for safe working conditions. Use of trench boxes or other type(s) of trench sheeting, shoring, or bracing shall not relieve the Contractor from any backfill or compaction requirements.

vii. Backfill material of the remainder of the trench shall follow the construction plan details as per the type of pipe and location of such trench. Backfill material shall be uniformly placed in maximum twelve (12) inch loose lifts and be mechanically consolidated in place as per the density and moisture content requirements specified within the geotechnical report and indicated on the construction plan trench details.

viii. All backfilling shall be done in such a manner that will not disturb or injure the pipe or structure over or against which it is being placed. Any pipe or structure injured, damaged, or moved from its proper line or grade during backfilling operations, shall be replaced or repaired and then re-backfilled as herein specified, at the expense of the Contractor.

ix. The above procedures are intended to be the minimum requirements for the required trench backfill and compaction. The Contractor shall ultimately be responsible for the pipe laying, backfill, and compaction of all utility trenches in such a manner to prevent any future settlement, movement, or

damage to the pipe, lawn / landscape, pavement surfaces, sidewalks, curbs, gutter, or other structures on the surface.

END OF SECTION 312100

SECTION 32 12 16

ASPHALT PAVING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section of Specifications covers the material and installation requirements for asphalt patching over excavated trenches in roads, parking lots and driveways.

B. This Section of Specifications covers material and installation requirements for asphalt overlay, asphalt full build-up in roads, parking lots, and driveways.

1.2 MEASUREMENT – Not applicable for lump sum project.

1.3 REFERENCES

A. Alabama Department of Transportation Standard Specifications for Highway Construction, Latest Edition.

1.4 QUALITY ASSURANCE

A. The work of asphalt paving shall be accomplished by skilled workmen experienced in the laying of asphalt.

B. All equipment shall be of a design and size to successfully accomplish the work.

1.5 PROJECT CONDITIONS

A. The Contractor shall comply with all environmental laws and requirements pertaining to the work.

B. The Contractor shall take adequate measures to control dust in the work area.

C. The Contractor shall thoroughly inspect the backfilled trench and assure himself that proper laying conditions exist.

D. The Contractor shall provide and maintain adequate and safe traffic control.

PART 2 – PRODUCTS

2.1 MATERIAL

A. Prime Coat:

i. Prime coat shall not be used unless approved in writing by The UA. The Contractor shall be responsible for keeping the crushed stone area wet in any and all means, methods, techniques, etc) necessary to maintain the proper moisture content at no additional costs to the project.

ii. If prime coat is approved for use by The UA, it shall be emulsified asphalt, Type AE-P, tar types RT2 or RT3, or cutback asphalts MC 250, RC70 or RC250 as defined in Section 804 of the Alabama Department of Transportation Standard Specifications.

iii. When approve for use by The UA, prime coat shall be applied at the rate of 0.22 to 0.25 gallons per

square yard over the entire area to be treated with asphalt.

B. Tack Coat:

i. Tack coat shall be emulsified asphalt type SS-1, SS-1h, or RS-2 or Asphalt Cement Grade AC-10 or AC-20 as defined in Section 804 of the State of Alabama Department of Transportation Standard Specifications.

ii. Tack Coat shall be applied at a rate not to exceed 0.10 gallons per square yard.

C. Asphalt Patch:

i. Asphalt paving used in patching shall be Improved Bituminous Concrete Binder as defined in Section 424 of the State of Alabama Department of Transportation Standard Specifications.

ii. Materials shall meet the requirements of Article 424.02 of the above- mentioned specifications.

iii. The Contractor shall refer to the drawings for the quantity of material to be applied per square yard.

D. Asphalt Paving:

i. Asphalt paving used in paving shall be Improved Bituminous Concrete Plant Mix, meeting the specification outlined in Section 424 of the State of Alabama Department of Transportation Specifications.

ii. Asphalt final layer placed for paving and/or overlay in streets, parking lots, drives, and patches shall be Improved Bituminous Concrete Wearing Surface, Mix "A" and all materials used shall conform to Article 424 of the State of Alabama Department of Transportation Specifications.

iii. The Contractor shall refer to the drawings for the quantity of material to be applied per square yard.

iv. Refer to The UA Asphalt Paving Checklist prior to proceeding with any paving operations.

E. Traffic striping and control markings shall conform to Sections 701 and 703 of the State of Alabama Department of Transportation Standard Specifications for Highway Construction. All striping, delineations, markers, etc., damaged or destroyed during the construction shall be replaced by the Contractor at his expense.

F. Before overlaying the street, the Contractor shall raise or lower all valve boxes, manholes and other embedded items, including items that have previously been paved over. No extra payment will be made for these adjustments.

2.2 EQUIPMENT

A. Equipment used in asphalt patching and/or asphalt paving shall meet the requirements of Article 410.03a of the State of Alabama Department of Transportation Specifications.

B. Equipment used in the application of Prime Coat and Tack Coat shall comply with Article 401.03a of the above-mentioned Specifications.

2.3 TEMPERATURE AND WEATHER REQUIREMENTS

A. Prime and Tack Coat:

i. Bituminous materials shall not be placed on wet surfaces or when the air temperature is below 60-degrees F.

ii. Bituminous materials shall not be placed when the temperature is expected to fall below freezing during the night regardless of the daytime temperature.

B. Asphalt Patching and Overlay:

i. The asphalt mixture shall be placed only upon an approved underlying course that is dry.

ii. Asphalt layers of 200-pounds per square yard or less shall not be placed when the air temperature is below 40-degrees F. The air temperature must be 40-degrees F. and rising before the spreading operation is started and the spreading operation shall be stopped when the air temperature is 45-degrees and falling.

iii. For asphalt layers over 200-pounds per square yard, the above temperatures shall be lowered by 5- degrees.

PART 3 – EXECUTION

3.1 EXECUTION

A. Prime and Tack Coat:

i. All loose material, dust and foreign material shall be removed from the surface. Cleaning shall be continued until all caked and loose dirt and dust are removed.

B. Asphalt Patching:

i. All designated areas to be patched shall be trimmed to neat vertical lines to the depth of patch specified. All loose material shall be removed. A prime or tack coat shall be applied as specified above. The asphalt shall be placed and compacted to a degree that further consolidation of the patch is not anticipated.

ii. Any patched areas that do consolidate shall be replaced or additional material brought in to bring the patch up to the surrounding level.

iii. All asphalt or concrete streets, parking areas and drives shall be patched the same day they are cut. Temporary or cold patch material may be used until the permanent patch can be placed; however, no extra payment will be made for temporary patching.

iv. The Contractor shall delineate with construction warning signs (lighted at night) any "bump" and/or rough patch areas that will greatly impact the public until the patch is complete and smoothly graded with no settlement.

3.2 APPLICATION

A. Prime and Tack Coat:

i. Prime and Tack Coat shall be uniformly applied at the rate specified by pressurized distributors.

ii. All areas to be treated with an asphalt surface treatment shall be maintained with moisture conditioning prior to placing asphalt. Prime coat shall not be used unless specifically directed by The UA.

B. Asphalt Patch and Overlay:

i. Asphalt patching may be applied with spreaders, by hand, or with motor graders. All areas inaccessible to large equipment shall be spread by hand.

ii. Asphalt patching shall be thoroughly compacted through the use of steel wheeled rollers and/or rubber-tired rollers. Density shall be as specified in the drawings or in the State of Alabama Department of Transportation Standard Specifications.

iii. Asphalt paving overlay shall be applied with spreaders; except in inaccessible areas spreading may be done by hand, uniformly placing the desired rate per square yard over the underlying surface.

iv. As soon as the mixture has set sufficiently to prevent cracking, the mixture shall be rolled with steel wheel and rubber-tired rollers to compact the mixture. Density shall be as specified in the drawings.

3.3 TESTING AND SURFACE REQUIREMENTS

A. Testing of the asphalt mixtures shall be performed at the discretion of the Architect. Testing shall include but not be limited to density tests and extraction tests.

B. The finished surface of asphalt overlays shall be checked with string, level and/or straightedge. The finished surface shall not vary more than 1/4" from the required sections as measured at right angles to the roadway centerline. The finished surface shall not vary more than 3/8" in any 25-foot section measured parallel to the centerline at the following locations: one foot inside of the edges of pavement, at the centerline and at other points as designated.

C. Refer to The UA paving checklist for additional requirements.

3.4 MAINTENANCE

A. The contractor shall maintain and protect the newly laid asphalt until final acceptance of the work.

END OF SECTION 321216

SECTION 32 12 17

MILLING OF EXISTING ASPHALT

PART 1 – GENERAL

1.1 SUMMARY

A. This Section shall cover the work of removing existing asphalt pavement by milling (planing).

1.2 MEASUREMENT – Not applicable for lump sum project.

1.3 REFERENCES

A. Alabama Department of Transportation Standard Specifications for Highway Construction, Latest Edition.

1.4 QUALITY ASSURANCE

A. The work of asphalt milling shall be accomplished by skilled workmen experienced in such scope of work.

B. All equipment shall be of a design and size to successfully accomplish the work.

1.5 PROJECT CONDITIONS

A. The Contractor shall comply with all environmental laws and requirements pertaining to the work.

B. The Contractor shall take adequate measures to control dust in the work area.

C. The Contractor shall provide and maintain adequate and safe traffic control.

PART 2 – PRODUCTS

A. EQUIPMENT
   1. The milling (planing) machines shall be:
      a. Self-propelled.
      b. Size and shape that allows traffic to pass through areas adjacent to the work when operations are being performed within open traffic areas.
      c. Be equipped with automatic grade and cross-slope controls.
      d. Equipped with means to prevent dust from escaping the milling operations.
      e. Capable of maintaining the required depth of cuts and cross-slope.
      f. Furnished with a lighting system for night work if night work is required.
      g. Provided with conveyors capable of removing the milled material and emptying it directly into trucks to be hauled away from the pavement surfaces.

PART 3 – EXECUTION

3.1 EXECUTION

A. Pavement Removal:

i. The existing pavement shall be removed to varying depths in a manner which will restore the pavement surface to a uniform longitudinal profile and cross section as shown on the plans or as directed by the Owner's Representative.

ii. The depth of removal shall be increased or decreased across the width of the pavement to obtain the required roadway cross slope. The Contractor may make multiple cuts to achieve the required depth of cut.

iii. The pavement removal shall be done to effectively minimize the amount of airborne dust. Wetting of the pavement may be required to minimize the airborne dust.

iv. The Contractor shall provide a means of drainage to prevent water accumulation on the surface where the pavement has been removed.

v. Unless otherwise noted on the plans, the pavement removal shall be limited to an area that will be covered with a surface treatment or a layer of pavement within seven (7) calendar days after milling has begun.

vi. The Contractor shall collect, transport and dispose the removed pavement material. The removed material shall become the property of the Contractor unless otherwise noted on the plans.

vii. After pavement removal and immediately prior to resurfacing or opening to traffic, the surface shall be thoroughly swept with a power broom to remove fine material and dust particles. Sweeping shall be conducted in a manner that will minimize the potential for creation of a traffic hazard and minimize the creation of airborne dust. Material removed by sweeping shall be collected, transported and disposed by the Contractor.

B. Final Milled Surface:

i. The final milled surface shall be a uniform finish on the grade and slope as required based on the finished pavement grades as indicated on the plans. The finish surface shall also not vary more than ¼" from a 10 ft straightedge placed anywhere on the surface of the milled area.

ii. The Contractor shall make any and all necessary adjustments to the milling equipment as necessary to milled surface within these tolerances.

iii. All loose material, dust and foreign material shall be removed from the surface. Cleaning shall be continued until all caked and loose dirt and dust are removed.

3.2 MAINTENANCE

A. The contractor shall maintain and protect the remaining pavement surface after milling operations until final asphalt placement is completed.

END OF SECTION 321217

SECTION 32 12 20

CRUSHED AGGREGATE BASE

PART 1 – GENERAL

1.1 WORK INCLUDED

A. This specification gives specific requirements for materials and installation of crushed aggregate base.

1.2 MATERIALS

A. Materials shall meet the requirements of the latest edition of the Alabama Department of Transportation Standard Specifications for Highway, Section 825, Gradation Type "B".

B. Only "limestone" shall be allowed for crushed aggregate base, no exceptions.

1.3 INSTALLATION

A. No material shall be placed until the preceding layer has been approved by the Owner's Geotechnical Representative. Such layer shall be properly shaped according to the contours and spot elevations shown on the grading plan.

B. Material shall be mixed to a uniform consistency by road-mixing, yard-mixing, or plant-mixing.

C. Materials found not meeting the requirements of this specification shall be removed by the Contractor or brought into conformance.

D. Material shall be spread to a uniform thickness and compacted to 100% S.P.D. as determined by ASTM D 698. Finished material shall be to the thickness shown in the drawings.

E. Material shall extend the full width and shaped to accept curbing as shown by the typical sections.

F. Material shall be kept at or near optimum moisture during the compaction process and until the succeeding layer is placed.

G. The Contractor shall shape the finished base to reasonably close conformity to the contours shown by the grading plan.

H. The Contractor shall maintain the base layer until such time as the succeeding layer is placed.

I. The Contractor shall install all underground utilities and sleeves prior to base installation. If base is installed, compacted tested, etc., and utilities are later installed, then the base shall be considered contaminated and shall be removed/reinstalled, recompacted, and retested at the Contractor's expense, no exceptions. Final base is not considered temporary stone; therefore, contamination shall not be allowed. Contaminated base shall be removed and replaced at the Contractor's expense.

J. When proof rolling is required by the Owner's Representative, it shall be proof rolled at a minimum with a fully loaded, triaxle dump truck. All proof rolling shall be done in the presence of the Owner's Representatives.

END OF SECTION 321220

SECTION 32 13 13

CONCRETE PAVING

PART 1 - GENERAL

1.1 PHILOSOPHY AND APPROACH

A. All concrete shall be designed, transported, placed, finished, and cured in accordance with American Concrete Institute (ACI) requirements. Components of the concrete mix shall meet applicable ANSI/ASTM requirements. Mix requirements and strength shall be specified by the Design Team for each item of construction. Structural drawings to be sealed by a registered structural engineer in the State of Alabama and contain the following:

1. Specify all loads used for design with complete strength calculations.

2. Shop drawings required for fabrication, grade, and placement of reinforcement, including joint locations and sealing compounds. Provide certification from (an independent testing laboratory) that mechanical connectors for steel reinforcing comply with applicable codes and engineering calculations.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes Concrete Paving:

1. Walks.

B. Related Requirements:

1. Section 03 30 00 "Cast-in-Place Concrete"
2. Section 07 92 00 “Joint Sealants”
3. Section 31 29 30 “Cast-in-Place Concrete (Sitework)”

1.4 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:

a. Concrete mixture design.
b. Quality control of concrete materials and concrete paving construction practices.
c. Review and finalize construction schedule and verify availability of materials.
d. Installer's personnel, equipment, and facilities needed to make progress and avoid delays. It is the responsibility of the concrete subcontractor to make the Owner aware of any problems, changes, etc. at this time.
e. Review plans for any problematic areas prior to construction.

2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:

a. Contractor's superintendent.
b. Concrete paving Subcontractor.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

C. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.7 INFORMATIONAL SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

C. Qualification Data: For manufacturer.

D. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.

7. Bonding agent or epoxy adhesive.
8. Joint fillers.

E. Material Test Reports: For each of the following:

1. Aggregates

F. Field quality-control reports.

G. Minutes of preinstallation conference.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C1077 and ASTM E329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.

D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

E. Mockups: Cast mockups of full-size sections of concrete pavement to demonstrate typical joints, surface finish, texture, color, and standard of workmanship.

1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
2. Notify Landscape Architect seven (7) days in advance of dates and times when mockups will be constructed.
3. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Landscape Architect and not less than 96 inches by 96 inches.
4. Obtain Landscape Architect's approval of mockup before starting construction.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Landscape Architect specifically approves such deviations in writing.
6. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
7. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
8. If not used as part of the completed Work, demolish and remove approved mockups from the site when directed by the Landscape Architect.

F. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:

    a. Contractor's superintendent.
    b. Independent testing agency responsible for concrete design mixtures.
    c. Ready-mix concrete producer.
    d. Concrete pavement subcontractor.

G. Codes and Standards: Comply with local governing regulations if more stringent than herein specified.

1.9 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

2.2 FORM MATERIALS

A. Form Materials:

1. Forms for Exposed Finished Concrete: Unless otherwise indicated, construct formwork for exposed concrete surfaces with plywood, metal, metal-framed plywood faced or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints to conform to joint system shown on drawings. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

2. Forms for Unexposed Finished Concrete: Form concrete surfaces which will be exposed in finished structure with plywood, lumber, metal, or other acceptable material. Proved lumber dressed on at least 2 edges and one side for tight fit.

3. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60; deformed.

B. Steel Wire: ASTM A82, plain, cold-drawn, steel.

C. Welded Wire Fabric: ASTM A185, welded steel wire fabric.

D. Welded Deformed Steel Wire Fabric: ASTM A497.

E. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI Specifications, unless otherwise approved by UA in advance.

2.4 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C150, Type I or II low alkali, unless otherwise acceptable to UA.

a. Use one brand of cement throughout project, unless otherwise acceptable to UA.

2. Fly Ash: ASTM C618, Type C or Type F. Limit use of fly ash to not exceed 25% of cement content by weight.

3. Normal-Weight Aggregates: ASTM C33/C33M, and as herein specified. Provide aggregates from a single source for exposed concrete.

a. For exterior exposed surfaces, do not use fine or coarse aggregates containing spalling-causing or deleterious substances.

b. Local aggregates not complying with ASTM C33 but which have shown by special test of actual service to produce concrete of adequate strength and durability may be used when acceptable to UA.

B. Air-Entraining Admixture: ASTM C260/C260M.

1. Products: Subject to compliance with requirements, provide one of the following:

a. "Sika Aer"; Sika Corp.

b. "MB-VR" or "MB-AE"; Master Builders

c. "Dorex AEA"; W.R. Grace

d. "Edoco 2001 or 2002"; Edoco Technical Products

C. Water: Potable and complying with ASTM C94/C94M.

2.5 CURING MATERIALS

A. Curing compound shall conform to the latest revised Standard Specifications for Liquid Membrane Forming Compounds for Curing Concrete. ASTM C309 or Chlorinated Rubber Sealer.

2.6 CONCRETE ACCESSORIES

A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork in preformed strips.

B. Bonding Agent: ASTM C1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Epoxy-Bonding Adhesive: ASTM C881/C881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:

1. Types I and II, non-load bearing on walkways and Types IV and V, load bearing on walks with vehicular traffic, for bonding hardened or freshly mixed concrete to hardened concrete.

D. Provide plastic expansion joint cap similar to "Snap-Cap", as manufactured by W.R. Meadows, where concrete walks or paving abuts the exterior wall of buildings.

1. Install expansion joint cap over top of expansion joint and pull out once concrete is cured prior to applying sealants.

E. Joint sealant: Semi-self-leveling, polyurethane, tintable, rated for traffic in areas sloped up to 10%. Color to match surrounding paving.

1. Tremco THC-901.
2. Approved substitute.

2.7 MIXES AND TESTING

A. Proportioning and Design of Mixes

1. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If trial batch method is used, use an independent testing facility acceptable to UA for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing unless otherwise acceptable to UA.

2. Submit written reports to UA of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed by UA.

3. Design Mixes to provide normal weight concrete with the following properties, as indicated on drawings and schedule: 3000 psi 28-day compressive strength; W'C ration, 0.58 maximum (non-air-entrained), .046 maximum (air entrained).

4. Use air-entraining admixture in exterior exposed concrete, unless otherwise indicated. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content as required.

5. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:

   a. Ramps, slabs, and sloping surfaces: Not more than 3".

   b. Reinforced Foundation Systems: Not less than 1" and not more than 3".

   c. Concrete Containing HRWR Admixture (Super Plasticizer): Not more than 8" after addition of HRWR to verify less than 3" slump concrete.

   d. Other Concrete: Not more than 4".

6. Testing: UA will employ a testing laboratory to perform tests and to submit test reports. However, UA is not obligated to perform the test for the convenience of the Contractor.

   a. Preparation of Concrete Cylinders: ASTM C31; one (1) set of three (3) for each day's pour exceeding five (5 c.y.) cubic yards, plus additional sets for each additional twenty-five (25 c.y.) cubic yards of each concrete class places in any one (1) day.

   b. Compressive Strength Tests: ASTM C39; one (1) specimen tested at seven (7) days, one (1) specimen tested at twenty-eight (28) days, and one (1) specimen retained in reserve for later testing if required.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Ground Granulated Blast-Furnace Slag Cement: 50 percent.
3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 4% to 6%

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Air entrained admixtures for concrete shall conform to the latest revised Standard Specifications for Air Entraining Admixtures for Concrete, ASTM C260. (6% +/- 2%)

F. Concrete Mixes:

1. Ready-Mix Concrete: Comply with requirements of ASTM C94, and as herein specified.

a. Air Temperature: Maximum allowable combined mixing, delivery, and placement time.

b. Less than 85 degrees: Per ASTM C94 unless a shorter time is necessary due to the job conditions, but 1 1/2 hours maximum.

c. 85 degrees - 90 degrees F: 75 minutes

d. Greater than 90 degrees F: 60 minutes

G. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 CONCRETE FORMWORK

A. Formwork to be designed by a professional engineer registered in the State of Alabama. Material should have sufficient strength to resist hydrostatic head without bow or deflection in excess of allowable tolerances. Proved chamfered edges and corners at exposed locations.

1. Design, erect, support, brace and maintain formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structures. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position.

2. Design formwork to be readily removable without impact, shock, or damage to cast-in-place concrete structures and adjacent materials.

3. Form Ties: Factory-fabricated, adjustable -length, removable or snap off metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal.

B. Unless otherwise indicated, provide ties so portion remaining within concrete after removal is 1" inside concrete and will not leave holes larger than 1: diameter in concrete surfaces.

3.4 CONCRETE REINFORCEMENT INSTALLATION

A. Submit shop drawings for fabrication, bending and placement of concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures: showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement. Include special reinforcement. Include special reinforcement required and openings through concrete structures.

1. Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars", for details and method of reinforcement placement and supports, and as herein specified.

2. Clean reinforcement of loose rust and mill scale, earth, ice and other materials which reduce or destroy bond with concrete.

3. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required.

4. Place reinforcement to obtain at least minimum coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement and operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surface.

5. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh and lace spices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 30’ maximum, unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

    a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.

2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies**,** reinforcement**,** or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

3.7 CONCRETE FINISHES

A. General: Do not add water to concrete surfaces during finishing operations.

B. Rough Form Finish: For formed concrete surfaces not exposed to view in the finish work by other construction, unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective area repaired and patched and fins and other projections exceeding 1/4" in height rubbed down or chipped off.

C. Smooth Form Finish: For formed concrete surfaces exposed to view, or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such a waterproofing, damp-proofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arrange orderly and symmetrically with a minimum of seams. Repair and patch defective areas with voids, fins or other projections, completely removed and smoothed.

D. Broom Finish: Apply broom finish to sidewalks, curb, and gutters and other areas as directed. Immediately after trowel finishing, slightly roughen concrete surface by brooming with fiber bristle perpendicular to main traffic route.

3.8 CONCRETE PROTECTION AND CURING

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Start curing as soon as free water has disappeared from concrete surface after placing and finishing. Keep continuously moist for not less than 7 days.

C. Curing Methods: Perform curing of concrete by curing and sealing compound, by moist curing, by moisture-retaining cover curing, and by combinations thereof, as herein specified.

D. Provide moisture control by one of the following methods:

1. Keep concrete surface continuously wet by covering with water.

2. Continuous water-fog spray

3. Covering concrete surface with specified absorption cover, thoroughly saturating cover with water, and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges with 4" lap over adjacent absorptive covers.

4. Coat concrete with curing and sealing compound as per manufacturer's recommendations.

3.9 WALKS, RAMPS, AND PEDESTRIAN TRAFFIC AREAS

1. Provide all exterior concrete ramps, walks, loading docks, aprons, and other such surfaces subject to weather with a non-slip broom finish.

2. Sidewalks and pedestrian pavements shall include welded wire mesh reinforcement or an approved equal. Fibermesh reinforcement is not an acceptable reinforcement.

3.10 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 (ACI 117M) and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-feet- (3-m-) long; unleveled straightedge not to exceed 1/2 inch (13 mm).
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches (13 mm per 300 mm) of tie bar.
5. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
6. Vertical Alignment of Dowels: 1/4 inch (6 mm).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.
8. Joint Spacing: 3 inches (75 mm).
9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
10. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspection agency to perform field tests and inspections and prepare test reports.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C172/C172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd., 5000 sq. ft. or fraction thereof of each concrete mixture placed each day.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.

5. Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C39/C39M; test one (1) specimen at seven days and two (2) specimens at 28 days.

    a. A compressive-strength test shall be the average compressive strength from two (2) specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

I. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

J. Prepare test and inspection reports.

3.12 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Landscape Architect.

B. Drill test cores, where directed by Landscape Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 13 20

CONCRETE CURB, GUTTER, AND SIDEWALKS

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the scope of work associated with Portland cement concrete curbs, gutters, and sidewalks.

1.2 REFERENCES

A. ASTM A1064 – Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

B. ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

C. ASTM C94 – Standard Specification for Ready-Mixed Concrete

D. ASTM C138 – Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

E. ASTM C143 – Standard Test Method for Slump of Hydraulic-Cement Concrete

F. ASTM C150 – Standard Specification for Portland Cement

G. ASTM C172 – Standard Practice for Sampling Freshly Mixed Concrete

H. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

I. ASTM D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

1.3 GENERAL

A. All concrete for items covered by this Section shall be Class C, Type 2 as per ALDOT Section 501, unless specified otherwise.

B. Concrete 28-day compressive strength, unless identified otherwise on the Construction Plans, shall be as follows:

i. Combination curb and gutter.....3000 psi

ii. Curb (no gutter).....3000 psi

iii. Valley gutter.....As indicated on plan details, minimum of 4000 psi

iv. Sidewalk.....As indicated on plan details, minimum of 4000 psi

v. For any item with no compressive strength specified.....4000 psi

C. The foundation below concrete sections shall be constructed or excavated to the required depths below the finish concrete. Any soft, loose, or unsuitable material shall be removed and replaced with suitable material, in layers not to exceed four (4) inches compacted.

1.4 FORMS

A. For curb, gutter, and combination curb / gutter sections, automatic extrusion type curb machine placement shall be used except for tie-ins and areas not suitable for machine installation (ADA ramps, connections to inlet structures, sharp radii, bends / breaks, etc.). The extrusion forms must be able to provide a section conforming to the dimensions, cross-section, lines, and grades shown on the construction plans. String / wire for machine guidance shall be required in order to check the grades prior to placement. Automatic extrusion type machines used for sidewalk installations may be used at the approval of the Owner following a mock-up installed by the Contractor with the form and machine proposed to be used. A minimum thirty (30) foot section of extruded sidewalk, complete with a sample expansion, contraction, and construction joint and any other sidewalk features required by the project such as but not limited to any "picture framing", joint spacing, tooling, curing compound, sealer, etc.

B. Except for radial sections, forms shall be of standard type metal or of fresh wood straight and free from warps and of sufficient length to hold the concrete true to line and grade without distortion. Wood forms shall have a top edge straight with no more than ¼" out of straightness. The forms shall provide the approved typical section and depth of the section as indicated on the Construction plans. Radial or curved forms may be of flexible metal or a wood form of approved design. Bent or damaged forms shall not be utilized.

C. All forms shall be securely staked, braced, and held together to the exact lines and grades and shall be kept sufficiently tight to prevent leakage of mortar. In radial sections, adequate number of bracing shall be used to provide a smooth and radial appearance. All forms shall be cleaned and oiled with a suitable oil immediately before concrete is placed against them to assist in a clean separation when the forms are removed.

D. In straight sections of concrete, an adequate number of braces shall be used to avoid warping or meandering to the finish concrete alignment.

E. Hand forming and pouring of sidewalks, curb, gutters, or combinations shall be of the highest quality. This pertains to areas where the Contractor makes tie-ins or pours sidewalks, curbing, valley gutter, etc., in decorative locations where machine extrusion is not possible. High quality will be considered consistent, straight pours, with almost no waving, depressions, or deviations in the general shape of the concrete section of sidewalk, curb, gutter, etc., required as shown on the plans. Low quality, non-aesthetically pleasing concrete work shall be removed and reinstalled at the Contractor's expense as directed by the Owner's Representative.

1.5 JOINTS

All expansion, contraction, and construction joints shall be as indicted on the construction plans. If not shown, joints shall be placed as follows:

A. For curb, gutter, and combination curb / gutter:

i. Expansion joints shall be ¾" wide and shall be placed to match those in concrete pavement where the two are adjacent.

ii. Expansion joints shall be placed where they terminate against concrete driveways and other concrete structures except inlets. Joints shall be placed at least 20 feet from the concrete structures at inlets.

iii. Expansion joint filler and sealer shall meet the requirements given in ALDOT Specifications Article 832.01 and 832.02. Joint filler shall extend from the bottom of the curb and / or gutter to within one (1) inch of the top. The sealer shall be ¾ of an inch thick and be recessed ¼ of an inch from the top.

iv. Contraction joints shall be placed to match those in concrete pavement where the two are adjacent,

but in no instance more than 10 feet between joints. The contraction joints shall be sawed or otherwise cut a minimum of two (2) inches deep by minimum ¼" wide and shall extend a minimum of two (2) inches below the finished pavement surface.

v. For integral curb and sidewalk sections, joint spacing shall follow that required by the integral sidewalk.

B. For sidewalks:

i. Expansion joints shall be a minimum of 3/8" wide. Expansion joints shall be placed where they terminate against concrete driveways and other concrete structures but in no instance more than 30 feet between joints.

ii. Expansion joint filler and sealer shall meet the requirements given in ALDOT Specifications Article 832.01 and 832.02. Joint filler board shall extend from the bottom of the sidewalk to within one (1) inch of the top. The depth of the sealer shall be ¾" and be recessed ¼" from the top of the sidewalk.

iii. Contraction joints shall be placed as indicated on the construction plans and / or as directed in the field by the Owner, but in no instance more than a distance equal to the width of the sidewalk. The contraction joints shall be trialed / tooled with a picture frame edge as per the plan details unless indicated otherwise. No saw cutting of joints will be acceptable. Depth of the joints shall be a minimum of ¼ of the overall concrete thickness with a width a minimum of ¼" wide.

iv. For integral curb and sidewalk sections, contraction joints in the curb shall extend a minimum of two (2) inches below the finished pavement surface.

PART 2 – PRODUCTS

2.1 MATERIALS

All materials shall conform to the requirements given in the Alabama Department of transportation Standard Specifications for Highway Construction, latest edition, Division 800, Materials, with the following Sections directly applicable:

A. Section 801 – Coarse Aggregate

B. Section 802 – Fine Aggregate

C. Section 804 – Bituminous Materials

D. Section 806 – Mineral Admixtures

E. Section 807 – Water

F. Section 808 – Air Entraining Additives

G. Section 809 – Chemical Admixtures for Concrete

H. Section 815 – Cement

I. Section 830 – Concrete Curing Material

J. Section 832 – Concrete Joint Fillers, Sealers, and Waterstop Admixtures

K. Section 835 – Steel Reinforcement

2.2 MIXTURES

A. Concrete shall be transit mixed concrete in accordance with ASTM C94.

B. Air content shall be in the range of 5.5 to 8.0 percent, slump shall be a maximum of 3 inches. Modifications and the use of admixtures may be submitted and shall be approved by the Owner.

2.3 CROSS SECTIONS

A. Sidewalk - Unless indicated otherwise on the plans, sidewalk shall have a minimum thickness of five (5) inches. Sidewalk through residential driveways shall have a minimum thickness of six (6) inches. Sidewalk through commercial driveways shall have a minimum thickness of seven (7) inches. Sidewalk through driveways or other special areas shall be reinforced as indicated on the construction plan details.

i. Sidewalk and ramp grades and/or slopes shall be compliant with all ADA requirements. Prior to placing any concrete, the Contractor shall confirm the grades and cross-slopes of all sidewalk and ADA ramps meet all such requirements. Any sections outside of compliance shall be removed and replaced at the Contractors expense.

ii. Sidewalks shall be constructed with a maximum transverse cross slope of 2.0 percent.

iii. Transverse slopes shall be at least 1.0 percent unless longitudinal drainage is provided.

iv. Under no circumstances shall sidewalks be constructed in such a manner that water will stand or pond on the sidewalk.

B. Driveways - Unless indicated otherwise on the plans, residential driveways shall have a minimum thickness of six (6) inches. Commercial driveways shall have a minimum thickness of seven (7) inches. Driveways shall be reinforced as indicated on the construction plan details.

C. Concrete Curbs, Gutters, and Combination Curb and Gutter – As indicated on the construction plan details.

i. Longitudinal grade of gutters shall not be constructed less than 0.50 percent, unless transverse drainage is provided.

ii. Under no circumstances shall curbs and/or gutters be constructed in such a manner that water will stand or pond in the gutter or the adjoining street.

PART 3 – EXECUTION

3.1 PLACING AND FINISHING CONCRETE

A. Concrete shall be placed in one (1) uniform lift. Separate lifts of concrete placement will not be acceptable.

B. The temperature of the concrete, at the time of placement and spreading, shall not be less than 50 degrees F or more than 90 degrees F. Concrete shall not be placed on an underlaying surface that is below 35 degrees F, nor when ambient temperatures are not 40 degrees F or more and rising.

i. Cold Weather Placement
When concrete is placed during seasons when there is a probability of ambient temperatures lower than 40 degrees F, heating equipment and materials shall be available to protect the contract from cold temperatures. The heating equipment and materials shall be used to enclose the uncured concrete and keep the air temperature inside the enclosure within the allowance ranges of temperature for the minimum required amount of time. If there is a possibility that ambient temperatures will be below 40 degrees F during the first 72 hours after placement of the concrete, the concrete shall be protected from the cold temperatures by keeping the surface at a temperature above 50 degrees F for the first 72 hours after placement and above 32 degrees F for an additional 72 hours. After these periods of time, the protective covering shall remain in place until the

temperature inside the protective covering reaches that of the surrounding temperature. The contractor shall furnish a minimum of two (2) continuous temperature reading thermometers for the measurements of the concrete surface temperatures.

ii. Hot Weather Placement
If there is a possibility that ambient temperatures will be above 90 degrees F during the placement of the concrete an approved retarder admixture shall be used in the concrete mixture. Cooling of the mixing water and / or aggregates or placing the concrete during the cooler part of the day may be allowed to keep the concrete below the maximum allowable temperature. In no instance shall a concrete mixture be placed when the temperature of the concrete is above 90 degrees F. Concrete shall not be placed against any surface (especially steel) when the temperature of that surface is greater than 120 degrees F. Surface watering may be used to cool such surface , but standing water will not be allowed at the time of concrete placement.

iii. Night Time Concrete placement
Concrete placement will only be allowed at night if the temperature of the concrete is above 90 degrees F and cannot be lowered or if the temperature of the surface that the concrete will be placed on is above 120 degrees F and cannot be lowered.

C. Prior to placement of any concrete for sidewalks, the Owner shall approve the orientation and layout of the formwork, and also the plan for all scored, contraction, construction, or expansion joints.

D. Prior to placement of any concrete, all forms shall be checked and approved for straightness, grade, alignment, etc.

E. All debris, loose, or foreign material shall be removed from the space to be occupied by the concrete. The subgrade shall be moist but not wet or muddy.

F. Immediately as concrete is placed, concrete shall be tamped, spaded, or vibrated sufficiently to produce a dense homogeneous mass and to bring the mortar to the surface. Particular attention shall be given to spading the concrete along and against the surface of the forms to prevent honeycombing and to secure a smooth, uniform surface.

G. After the forms are filled, the concrete shall be struck off with a template matching the shape and dimensions as required by the plan details. The exposed surface shall then be finished smooth with a wooden or similar float in a manner to provide a smooth, compact, even, and true top surface. Plastering with mortar to build up or finish will not be acceptable after the concrete has set. The surface of the gutter and the face and top of curb shall be checked with a 10-foot straightedge. Any irregularities more than ¼ of an inch in the 10-foot section shall be corrected. The alignment and grade shall not at any point vary more than ¼ of an inch from that established by the plans.

H. Immediately after the finishing operation is completed, the concrete shall be cured for a minimum period of 72 hours in order to prevent plastic shrinkage cracking. Curing methods shall be as provided by ALDOT Article 450.03(m).

3.2 MATERIAL CLEAN-UP AND DISPOSAL

A. The Contractor shall be responsible for clean-up of all concrete wash out, excess from forms, etc. No concrete matter shall be left in place once the forms have been removed. All such excess shall be removed and disposed of off-site. Such material shall not be deposited or remain along the edges of the concrete or the surrounding areas.

B. The Contractor shall follow all ADEM guidelines for any wash-out pits or cleanup water from concrete trucks, chutes, or other tools and equipment used in the placement of the concrete.

END OF SECTION 321320

SECTION 32 14 00

UNIT PAVING

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Brick pavers.
2. Concrete pavers.

B. Related Requirements:

1. Division 07 Roofing sections.
2. Division 32 Concrete Paving sections.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data:

1. For materials other than water and aggregates.
2. For the following:

    a. Pavers.
    b. Mortar and grout materials.
    c. Edge restraints.
    d. Precast concrete curbs.

B. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C136.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.

1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C67.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified unit paving installer. Installer's field supervisor shall have Concrete Paver Installer Certification from the Interlocking Concrete Pavement Institute (ICPI) with the following designations:

1. Commercial Paver Technician Designation.

B. Mockups: Build mockups to verify selections made under Sample submittals; to demonstrate aesthetic effects; and to set quality standards for material and execution.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at the time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

1.8 FIELD CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of unit paver, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

1. Brick Pavers: Pine Hall Brick Co., 800-952-7425, www.pinehallbrick.com. Campus standard; no subsititution.
2. Large Format Concrete Pavers:

2.2 BRICK PAVERS

A. Brick Pavers, Heavy Vehicular Paving Brick: ASTM C1272, Type F, Application PX. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.

1. Thickness: 2-3/4 inches
2. Face Size: 4 by 8 inches.
3. Color: English Edge Full Range.
4. Manufacturer: Pine Hall Brick; 2701 Shorefair Drive; Winston-Salem, NC 27105; 800.952.7425; pinehallbrick.com. Campus standard; no substitution.

B. Efflorescence: Brick shall be rated "not effloresced" when tested according to ASTM C67.

C. Temporary Protective Coating: Precoat exposed surfaces of brick pavers with a continuous film of a temporary protective coating that is compatible with brick, mortar, and grout products and can be removed without damaging grout or brick. Do not coat unexposed brick surfaces; handle brick to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.

2.3 CONCRETE PAVERS

A. Concrete Pavers, Solid Interlocking Paving Units: Complying with ASTM C936 and resistant to freezing and thawing when tested according to ASTM C67, made from normal-weight aggregates.

B. Large-format, heavy vehicular pavers:
1. Thickness: 100 mm
2. Face Size: 12 by 24 inches, nominal.
3. Surface Texture: Flat top.
4. Color: As selected by Landscape Architect from manufacturer’s full range.
5. Manufacturer: Tremron; 2885 St. Clair Street; Jacksonville, FL 32254; www.tremron.com. Basis of design.

C. Bullnose coping pavers:
1. Thickness: 60 mm.
2. Face size: 4 by 9 inches, nominal.
3. Finish: Standard.
4. Color: As selected by Landscape Architect from manufacturer’s full range
5. Manufacturer: Tremron; 2885 St. Clair Street; Jacksonville, FL 32254; www.tremron.com. Basis of design.

2.4 CURBS AND EDGE RESTRAINTS

A. Job-Built Concrete Edge Restraints: Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 4000 psi.

2.5 ACCESSORIES

A. Cork Joint Filler: Preformed strips complying with ASTM D1752, Type II.

B. Compressible Foam Filler: Preformed strips complying with ASTM D1056, Grade 2A1.

2.6 AGGREGATE SETTING-BED MATERIALS

A. Sand for Leveling Course: Polymeric Sand to match UA standards.

B. Sand for Joints: Polymeric Sand swept into joints to match UA standards.

1. Provide sand of color needed to produce required joint color.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

C. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing is turned up or flashed against vertical surfaces.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. See Paver detail in Drawings for installation methods.

B. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

C. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

D. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

E. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.

F. Joint Pattern: as indicated on Drawings.

G. Paves over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.
   1. Provide joint filler at waterproofing that is turned up on vertical surfaces.

H. Tolerances:

   1. Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) or 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.

I. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
   1. Install job-built concrete edge restraints to comply with Division 03 Cast-in-Place Concrete and Division 32 Decorative Concrete Paving sections.

3.3 AGGREGATE SETTING BED APPLICATIONS

A. Place leveling course and screed to depth indicated, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.

B. Treat leveling course with herbicide to inhibit growth of grass and weeds.

C. Set pavers with a minimum joint width of 1/16 inch and a maximum of 1/8 inch, being careful not to disturb leveling base. If pavers have spacer lugs, place pavers hand-tight against spacer lugs. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch with pieces cut to fit from full-size unit pavers.
   1. Follow guidance in drawings for minimum sizes of cut pavers.

D. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3,500- to 5,000-lbf compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
   1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches of uncompacted pavers adjacent to temporary edges.
   2. Before ending each day's work, compact installed concrete pavers except for 36-inch width of uncompacted pavers adjacent to temporary edges (laying faces).
   3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are withing 36 inches of laying face.

4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.

E. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

F. Do not allow traffic on installed pavers until sand has been vibrated into joints.

G. Repeat joint-filling process 30 days later.

H. Where polymeric sand is to be installed in joints, follow manufacturer's instructions for filling joints and activating product.
1. Protect pavers to receive polymeric sand from cold and moisture until polymeric sand is placed and cured.

3.4 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Cleaning: Remove excess material from paver surfaces. Wash and scrub clean where necessary.
1. Remove temporary protective coatings as recommended by coating manufacturer and as acceptable to paver manufacturer.
2. Do not allow protective coatings to enter drains. Trap, collect, and remove coating material.

END OF SECTION

SECTION 32 22 90

EROSION CONTROL

PART 1 – GENERAL

1.1 SUMMARY

A. This section of specifications covers the requirements of the contractor to protect the project site and adjoining properties from soil erosion and runoff, reviews methods of construction, erosion control measures, maintenance of erosion control features, and construction runoff permitting.

PART 2 – PRODUCTS

2.1 MATERIALS

All materials used for erosion and sedimentation control on the project shall follow the guidelines and requirements within the Alabama Handbook for Erosion Control, Sedimentation Control, and Stormwater Management on Construction Sites and Urban Areas, latest edition.

A. Temporary Berm. Temporary berm is constructed of compacted soil or riprap, with or without a shallow ditch, at the top of fill slopes or transverse to the centerline of fills. These berms are used temporarily at the top of newly constructed slopes to prevent excessive erosion until permanent controls are installed or slopes stabilized.

B. Temporary Slope Drain. Temporary slope drain is a facility consisting of temporary earthen swale, stone gutters, fiber mats, plastic sheets, concrete or asphalt gutters, half-round pipe, metal pipe, plastic pipe, sod or other material acceptable to the Owner that may be used to carry water down slopes to reduce erosion. These items shall be required at no additional compensation to manage the stormwater runoff during construction.

C. Sediment Structures. Sediment basins, ponds, and traps are prepared storage areas constructed to trap and store sediment from erodible areas in order to protect properties and stream channels below the construction areas from excessive siltation.

D. Check Dams. Check dams are barriers composed of logs and poles, large stones, or other materials placed across a natural or constructed drainageway in order assist in reducing run-off velocities and to protect properties and stream channels below the construction areas from excessive siltation.

E. Temporary Seeding and Mulching. Temporary seeding and mulching are measures consisting of seeding, mulching, fertilizing, and matting utilized to reduce erosion. All cut and fill slopes, including waste sites and borrow pits, shall be seeded when and where necessary to control erosion.

F. Brush Barriers. Brush barriers shall consist of brush, tree trimmings, shrubs, plants, and other approved refuse from the clearing and grubbing operations. Brush barriers are placed on natural ground at the bottom of fill slopes, where the most likely erodible areas are located, to retain sedimentation particles.

G. Baled Hay or Straw Checks. Baled hay or straw erosion checks are temporary measures to control erosion and prevent siltation. Bales shall be either hay or straw, containing five (5) cubic feet or more of material. Baled hay or straw checks shall be used where the existing ground slopes toward or away from the embankment along the toe of slopes, in ditches, or other areas where siltation erosion or water runoff is a problem.

H. Temporary Silt Fences. Silt fences are temporary measures utilizing woven wire or other approved material attached to posts with filter cloth composed of burlap, plastic filter fabric, etc., attached to the upstream side

of the fence to retain the suspended silt particles in the run-off water.

PART 3 – EXECUTION

3.1 GENERAL

A. A National Pollutant Discharge Elimination System (NPDES) General Permit Number ALR100000 (permit) from the Alabama Department of Environmental Management (ADEM) for discharge associated with regulated construction activity shall not be required since the disturbances will be less than one (1) acre. The contractor shall still be required to follow all regulations established by the Environmental Protection Agency (EPA) and ADEM in regards to disturbances on the project. The Contractor shall be responsible for providing a Qualified Credentialed Inspector (QCI) for monitoring oil, grease, other contaminates. The QCI shall inspect all BMP's daily and keep daily inspection reports in a log book that shall be submitted for review by the Owner's Representative prior to approval of the monthly pay request. The cost of any and all inspections, monitoring, reporting, and associated documentation shall be the responsibility of the Contractor.

B. The Contractor shall be responsible for providing the necessary field representative to inspect all BMP's daily and keep daily inspection reports in a log book as required by the permit (even though permit is not required) that shall be submitted for review by the Owner's Representative prior to approval of the monthly pay request. The Contractor shall also be responsible for all aspects of monitoring oil, grease, fuel / fuel tanks, fertilizers, or other contaminates as part of Part III.E of the permit. The cost of any and all inspections, monitoring, reporting, and documentation which the Contractor is responsible for shall be incidental to the overall cost of the project.

C. The Contractor shall exercise planning and forethought in coordinating the work of protecting the project and adjoining properties from soil erosion by effective and continuous erosion control methods of either a temporary or a permanent nature. This shall also include measures to prevent soil, mud, debris, contaminants from tracking and accumulating on streets, roads, other surfaces, leaving the project area, and / or entering into the storm drainage system ultimately leading to the streams or other bodies of water.

D. The erosion control plan and details included with the construction plans represents the minimum and shall be considered as a guide for the Contractor, not inclusive of all items potentially necessary. Based on the Contractors anticipated means, methods, techniques, sequences along with their proposed project phasing, prior to beginning construction the Contractor shall develop a detailed erosion control plan based on their intended scope. As part of the Owner Pre-Construction meeting, such plan shall be reviewed with any expected problem areas in regards to the erosion control work pointed out. Different solutions shall be discussed so that the best method might be determined. It is ultimately the responsibility of the Contractor to develop and implement a final detailed erosion control plan on the project.

E. The Contractor shall plan his clearing work and his entire construction operations in such a manner as to effectively control soil erosion and prevent pollution of streams, ponds, and/or drains as would result from silt or soil runoff or as would result from any materials used in the construction operations such as oil, grease, paints, chemicals, or any construction debris.

F. The Contractor shall intercept and protect drainage from the construction site by means of silt fences, silt barriers, sedimentation traps, or other measures as required.

G. Silt fences, wherever used on the site, shall consist of fabric securely fastened in place or, if approved, permeable-barrier fabric designed to filter water and retain silt. Fabric shall be set securely in the ground and firmly held in place.

H. The erosion control work shall cover all disturbed areas within the project. Erosion control work shall not be limited to the project area but shall include all disturbed areas associated with any staging, material laydown,

and / or storage.

3.2 CONSTRUCTION & INSTALLATION OF BMP'S

A. The Contractor shall use any and all acceptable methods necessary to control soil erosion and prevent the flow of sediment to the maximum extent possible. These methods shall include, but not be limited to, the use of silt fences, waddles, check dams, water diversion structures, diversion ditches, and settling basins.

B. Construction operations shall be restricted to the areas of work which must be entered for the construction of temporary or permanent facilities. The Owner's Representative reserves the right to limit the surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow, and fill operations and to direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of any surrounding property, drainages, wetlands, and / or adjacent watercourses. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains, and use of temporary mulches, mats, or other best management practices (BMP's) or methods as necessary to control erosion.

C. Excavated soil material shall not be placed adjacent to any surrounding property, drainages, wetlands, and / or adjacent watercourses in a manner that will cause it to be washed away by high water or runoff. Earthen berms or diversions shall be constructed to intercept and divert runoff water away from such areas. Diversion outlets shall be stable or shall be stabilized by means acceptable to the Owner. If, for any reason, construction materials are washed away during the course of construction, the Contractor shall immediately remove those materials from the fouled areas as directed by the Owner at no cost to the project.

D. The Contractor shall not pump silt-laden water from trenches or other excavations into wetlands or adjacent watercourses. Instead, silt-laden water from excavations shall be discharged within areas surrounded by baled hay, sediment traps, or other appropriate BMP's to ensure that only sediment-free water is returned to the watercourses. Damage to vegetation by excessive watering or silt accumulation in the discharge area(s) shall be avoided.

E. Prohibited construction procedures include, but are not limited to, the following:
   i. Dumping of spoil material into any streams, wetlands, surface waters, or unspecified locations.
   ii. Indiscriminate, arbitrary, or capricious operation of equipment in wetlands or surface water areas.
   iii. Pumping of silt-laden water from trenches or excavations into surface waters or wetlands.
   iv. Damaging vegetation adjacent to or outside of the construction area limits.
   v. Disposal of trees, brush, debris, paints, chemicals, asphalt products, concrete curing compounds, fuels, lubricants, insecticides, wash-water from concrete trucks or hydro-seeders, or any other pollutant in wetlands, surface waters, or unspecified locations.
   vi. Permanent or unauthorized alteration of any stream.

3.3 MAINTENANCE

A. The temporary erosion control features installed by the Contractor shall be acceptably maintained by the Contractor until no longer needed or permanent erosion control methods are installed.

B. Silt fences shall have sediment deposits removed if it reaches a depth of fifteen inches (15") or ½ the height of the fence. Sediment removed from the silt fence shall be removed from the site.

C. In the event that temporary erosion and pollution control measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of work as scheduled, and are ordered by the Owner or the Owner's Representatives, such work shall be performed by the Contractor at his own

expense.

3.4 FINES, FEES, PENALTIES

A. The Contractor shall be responsible for any fines, fees, penalties, claims, legal actions, disputes, etc. arising from any faulty or negligent erosion control practices as levied by ADEM, EPA, local governments, or any such passed to the Owner.

END OF SECTION 322290

SECTION 32 30 00

CAST-IN-PLACE CONCRETE (CIVIL)

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes requirements for cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the Storm Structures.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

PART 2 - SUBMITTALS

2.1 PRODUCT DATA (FOR EACH TYPE OF PRODUCT INDICATED):

A. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

B. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

C. Material Certificates: For each of the following, signed by manufacturers:

i. Curing compounds.

ii. Bonding agents.

iii. Repair materials.

D. Field quality-control test and inspection reports.

2.2 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

i. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.

D. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

i. ACI 301, "Specification for Structural Concrete," Sections 1 through 5.

ii. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

E. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

2.3 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

PART 3 - PRODUCTS

3.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

i. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

ii. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

3.2 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

i. Plywood, metal, or other approved panel materials.

ii. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:

a. High-density overlay, Class 1 or better.

b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.

c. Structural 1, B-B or better; mill oiled and edge sealed.

d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces. Formulate form-release agent with rust inhibitor for steel form-facing materials.

D. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

a. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.

3.3 STEEL REINFORCEMENT

A. Reinforcing bars: ASTM A615/A 615M, Grade 60 (Grade 420), deformed.

3.4 REINFORCEMENT ACCESSORIES

A. Joint dowel bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain steel bars, cut bars to true length.

B. Bar supports: Bolsters, chairs, spacers, and other devices for spacing, supporting and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practices", of greater compressive strength than the concrete and as follows:

   i. For concrete surfaces exposed to view where legs of wire bar support contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless steel bar supports.

3.5 CONCRETE MATERIALS

A. Cementitious material: Use the following cementitious materials, of the same type, brand, and source throughout the project:

   i. Portland cement: ASTM C 150, Type I or II, supplemented with the following:

      a. Fly ash: ASTM C 618, Class C or F.

      b. Ground granulated blast furnace slag: ASTM C 989, Grade 100 or 120.

B. Normal-weight aggregate: ASTM C 33, Class 3S coarse aggregate or better, graded. Provide aggregate from a single source.

   i. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.

   ii. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 94/C 94M and potable.

3.6 ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

   i. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.

   ii. Retarding Admixture: ASTM C 494/C 494M, Type B.

   iii. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.

   iv. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.

   v. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.

   vi. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

3.7 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete. Available Products:

   i. Axim Concrete Technologies; Cimfilm.

ii. Burke by Edoco; BurkeFilm.

iii. ChemMasters; Spray-Film.

iv. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; Aquafilm.

v. Dayton Superior Corporation; Sure Film.

vi. Euclid Chemical Company (The); Eucobar.

vii. Kaufman Products, Inc.; Vapor Aid.

viii. Lambert Corporation; Lambco Skin.

ix. L&M Construction Chemicals, Inc.; E-Con.

x. MBT Protection and Repair, Div. of ChemRex; Confilm.

xi. Meadows, W. R., Inc.; Sealtight Evapre.

xii. Metalcrete Industries; Waterhold.

xiii. Nox-Crete Products Group, Kinsman Corporation; Monofilm.

xiv. Sika Corporation, Inc.; SikaFilm.

xv. Symons Corporation, a Dayton Superior Company; Finishing Aid.

xvi. Unitex; Pro-Film.

xvii. US Mix Products Company; US Spec Monofilm ER.

xviii. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

i. Available Products:

a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.

b. Burke by Edoco; Aqua Resin Cure.

c. ChemMasters; Safe-Cure Clear.

d. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; W.B. Resin Cure.

e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).

f. Euclid Chemical Company (The); Kurez DR VOX.

g. Kaufman Products, Inc.; Thinfilm 420.

h. Lambert Corporation; Aqua Kure-Clear.

i. L&M Construction Chemicals, Inc.; L&M Cure R.

j. Meadows, W. R., Inc.; 1100 Clear.

k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.

l. Symons Corporation, a Dayton Superior Company; Resi-Chem Clear Cure.

m. Tamms Industries, Inc.; Horncure WB 30.

n. Unitex; Hydro Cure 309.

o. US Mix Products Company; US Spec Maxcure Resin Clear.

p. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

3.8 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.

i. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.

ii. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.

iii. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.

iv. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.

i. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.

ii. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.

iii. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.

iv. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

3.9 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

i. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials:

i. Fly Ash: 25 percent.

ii. Combined Fly Ash and Pozzolan: 25 percent.

iii. Ground Granulated Blast-Furnace Slag: 50 percent.

iv. Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.

v. Silica Fume: 10 percent.

vi. Combined Fly Ash, Pozzolans, and Silica Fume: 35 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.

vii. Combined Fly Ash or Pozzolans, Ground Granulated Blast-Furnace Slag, and Silica Fume: 50 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete to .30 percent by weight of cement.

D. Admixtures: Use admixtures according to manufacturer's written instructions.

i. Use water-reducing, high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.

ii. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

iii. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

3.10 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Proportion normal-weight concrete mixture as follows:

i. Minimum Compressive Strength: 4000 psi at 28 days.

ii. Maximum Water-Cementitious Materials Ratio: 0.45

iii. Slump Limit: 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1-inch.

iv. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.

3.11 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

3.12 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116, and furnish batch ticket information.

B. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 4 - EXECUTION

4.1 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:

i. Class A, 1/8 inch for smooth-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

i. Install keyways, reglets, recesses, and the like, for easy removal.

ii. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

I. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

J. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

K. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

4.2 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

i. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."

4.3 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.

i. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.

ii. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Engineer.

4.4 SHORES AND RESHORES

A. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation, and removal of shoring and reshoring.

i. Do not remove shoring or reshoring until measurement of slab tolerances is complete.

B. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

4.5 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

i. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

4.6 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.

i. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.

ii. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.

iii. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.

iv. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.

4.7 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement.

C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.

i. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be

placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

i. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.

ii. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

iii. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

i. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.

ii. Maintain reinforcement in position on chairs during concrete placement.

iii. Screed slab surfaces with a straightedge and strike off to correct elevations.

iv. Slope surfaces uniformly to drains where required.

v. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

i. When average high and low temperature is expected to fall below 40°F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.

ii. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

iii. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

G. Hot-Weather Placement: Comply with ACI 301 and as follows:

i. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

ii. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

4.8 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed- surface irregularities.

i. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

   i. Apply to concrete surfaces exposed to public view.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:

   i. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

   ii. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one-part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.

   iii. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one-part portland cement and one-part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

4.9 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

4.10 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

D. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

   i. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

      a. Water.

      b. Continuous water-fog spray.

c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

ii. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.

b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.

iii. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

a. After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer.

E. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

4.11 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

i. Defer joint filling until concrete has aged at least one month(s). Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semi-rigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

4.12 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Engineer. Remove and replace concrete that cannot be repaired and patched to Engineer's approval.

B. Patching Mortar: Mix dry pack patching mortar, consisting of one-part portland cement to two and one-half parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

i. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension in solid concrete, but not less than 1 inch in depth. Make edges of cuts perpendicular to concrete

surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.

ii. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.

iii. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Engineer.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

i. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.

ii. After concrete has cured at least 14 days, correct high areas by grinding.

iii. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.

iv. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.

v. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.

vi. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

vii. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Engineer's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Engineer's approval.

4.13 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner may engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Inspections:

i. Steel reinforcement placement.

ii. Steel reinforcement welding.

iii. Verification of use of required design mixture.

iv. Concrete placement, including conveying and depositing.

v. Curing procedures and maintenance of curing temperature.

vi. Verification of concrete strength before removal of shores and forms from beams and slabs.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

i. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.

ii. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.

iii. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.

iv. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.

v. Compression Test Specimens: ASTM C 31/C 31M.

a. Cast and laboratory cure two sets of three standard cylinder specimens for each composite sample.

b. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.

i. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.

ii. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.

iii. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.

iv. Strength of each concrete mixture will be satisfactory if every average of any three-consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

v. Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

vi. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.

vii. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Engineer.

viii. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

ix. Correct deficiencies in the Work that test reports and inspections indicate does not comply with the Contract Documents.

END OF SECTION 323000

SECTION 32 70 00

PAINTING AND STRIPING

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes all temporary and permanent painting and striping of the parking areas, roadways, and pedestrian crosswalks.

1.2 PRODUCTS AND REFERENCE SPECIFICATIONS

A. All materials, equipment, application methods, cleaning and installation shall be in accordance with Alabama Department of Transportation Standard Specifications, Latest Edition, Sections 701, 856, and 857, except as modified herein.

1.3 APPLICATION/EXECUTION

A. Prepare surface in accordance with ALDOT 701.

B. Rate of paint application shall not exceed 80 square feet per gallon.

C. Temporary painting shall be done on all areas including striping, pedestrian walkways and parking within the roadways immediately after completion of the asphalt placement and after utility installations that eliminate substantial portions of the existing striping. Permanent painting and thermoplastic striping of the roadways and parking lot shall be done after the asphalt has cured for fourteen (14) days.

END OF SECTION 327000

SECTION 32 84 00

PLANTING IRRIGATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Piping.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.

B. Related Sections:

1. Section 22 04 01 “General Plumbing Requirements.”

1.3 DEFINITIONS

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. ET Controllers: EvapoTranspiration Controllers. Irrigation controllers which use some method of weather based adjustment of irrigation. These adjusting methods include use of historical monthly averages of ET; broadcasting of ET measurements; or use of on-site sensors to track ET.

D. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 PERFORMANCE REQUIREMENTS

A. Irrigation zone control shall be automatic operation with controller and automatic control valves.

B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.

C. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:

1. Irrigation Main Piping: 200 psig.
2. Circuit Piping: 150 psig.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics**,** and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions such as signs and light standards.

B. Qualification Data: For qualified Installer.

C. Zoning Chart: Show each irrigation zone and its control valve.

D. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sprinklers, controllers, and automatic control valves to include in operation and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Impact Sprinklers: Equal to 2 percent of amount installed for each type and size indicated, but no fewer than 5 units.
2. Spray Sprinklers: Equal to 2 percent of amount installed for each type and size indicated, but no fewer than 5 units.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: A minimum of five (5) years' experience installing automatic irrigation systems of similar size and value.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.11 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than seven (7) days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. PVC Pipe: ASTM D1785, PVC 1120 compound, Schedule 40.

1. PVC Socket Fittings: ASTM D2466, Schedule 40.
2. PVC Threaded Fittings: ASTM D2464, Schedule 80.

3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

C. PVC Pipe, Pressure Rated: ASTM D2241, PVC 1120 compound, [SDR 21] [and] [SDR 26].

1. PVC Socket Fittings: ASTM D2467, Schedule 80.
2. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.2 PIPING JOINING MATERIALS

A. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 ENCASEMENT FOR PIPING

A. Standard: ASTM A674 or AWWA C105.

B. Form: Sheet or tube.

C. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness or high-density, cross-laminated PE film of 0.004-inch (0.10-mm) minimum thickness.

D. Color: Black or Natural.

2.4 MANUAL VALVES

A. Curb Valves:

1. Standard valve as provided or required by local water authority.
2. Description:

a. Standard: AWWA C800.
b. NPS 1 (DN 25) and Smaller Pressure Rating: 100 psig (690 kPa) minimum
c. NPS 1-1/4 to NPS 2 (DN 32 to DN 50) Pressure Rating: 80 psig (550 kPa) minimum
d. Body Material: Brass or bronze with ball or ground-key plug.
e. End Connections: Matching piping.
f. Stem: With wide-tee head.

B. Curb-Valve Casing:

1. Standard: Similar to AWWA M44 for cast-iron valve casings.
2. Top Section: Telescoping, of length required for depth of burial of curb valve.
3. Barrel: Approximately 3-inch (75-mm) diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.

6. Base Support: Concrete collar.

C. Shutoff Rods for Curb-Valve Casings: Furnish one steel, tee-handle shutoff rod(s) with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve for Project.

D. Brass Ball Valves:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

E. Bronze Gate Valves:
1. Description:

a. Standard: MSS SP-80, Type 2.
b. Class: 125.
c. CWP Rating: 200 psig (1380 kPa).
d. Body Material: ASTM B62 bronze with integral seat and screw-in bonnet.
e. Ends: Threaded or solder joint.
f. Stem: Bronze, nonrising.
g. Disc: Solid wedge; bronze.
h. Packing: Asbestos free.
i. Handwheel: Malleable iron, bronze, or aluminum.

2.5 PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Type as noted and described in the Drawings.
2. Description:

a. Standard: ASSE 1003.
b. Body Material: Bronze for NPS 2 (DN 50) and smaller; cast iron for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
c. Pressure Rating: Initial pressure of 150 psig (1035 kPa).
d. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

B. Water Control Valves:

1. Type as noted and described in the Drawings.

2. Description: Pilot-operation, diaphragm-type, single-seated main water control valve. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.

    a. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
    b. Pattern: Globe-valve design.
    c. Trim: Stainless steel.
    d. Pressure Rating: Initial pressure of 150 psig (1035 kPa) minimum.
    e. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.

2.6 AUTOMATIC CONTROL VALVES

A. Bronze, Automatic Control Valves:

1. Type as noted and described in the Drawings.
2. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

B. Plastic, Automatic Control Valves:

1. Type as noted and described in the Drawings.
2. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.7 AUTOMATIC DRAIN VALVES

A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig (17 to 20 kPa).

2.8 TRANSITION FITTINGS

A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

2.9 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.

B. Pressure Gages: ASME B40.1. Include 4-1/2-inch- (115-mm-) diameter dial, dial range of two times system operating pressure, and bottom outlet.

2.10 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.

B. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:

1. Type as noted and described in the Drawings.
2. Description:

    a. Body Material: ABS.
    b. Nozzle: ABS.
    c. Retraction Spring: Stainless steel.
    d. Internal Parts: Corrosion resistant.

C. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:

1. Type as noted and described in the Drawings.
2. Description:

    a. Case: ABS.
    b. Pop-up Height: as noted in the Drawings, aboveground to nozzle.
    c. Sprinkler Construction: ABS and other corrosion-resistant metals.

D. Plastic, Surface Spray Sprinklers:

1. Type as noted and described in the Drawings.
2. Description:

    a. Body Material and Flange: ABS.
    b. Pattern: Fixed, with flow adjustment.

E. Plastic, Pop-up Spray Sprinklers:

1. Type as noted and described in the Drawings.
2. Description:

    a. Body Material: ABS.
    b. Nozzle: ABS.
    c. Retraction Spring: Stainless steel.
    d. Internal Parts: Corrosion resistant.
    e. Pattern: Fixed, with flow adjustment.

F. Plastic Shrub Sprinklers:

1. Type as noted and described in the Drawings.
2. Description:

    a. Body Material: ABS or other plastic.
    b. Pattern: Fixed, with flow adjustment.

2.11 QUICK COUPLERS

A. Type as noted and described in the Drawings.

B. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

1. Locking-Top Option: Vandal-resistant locking feature. Include two matching keys.

2.12 CONTROLLERS

A. Toro ‘Sentinel’ controller. University standard; no substitute.

B. Description:

1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.

    a. Body Material: Stainless-steel sheet metal.
    b. Mounting: Freestanding type for concrete base.

3. Control Transformer: 24-V secondary, with primary fuse.
4. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.

    a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
    b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
    c. Surge Protection: Metal-oxide-varistor type on each station and primary power.

5. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
6. Smart Controllers: Use ET, tested in accordance with IA SWAT Climatological Based Controllers 8th Draft Testing Protocol and compliant with ASHRAE Standard 189.1.
7. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

    a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
    b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
    c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

8. Concrete Base: Reinforced precast concrete not less than 36 by 24 by 4 inches thick, and 6 inches greater in each direction than overall dimensions of controller. Include opening for wiring.

2.13 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Amerek valve box with locking lid. University standard; no substitutions.
2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

    a. Size: As required for valves and service.
    b. Shape: Round (ball and gate valves), 9” dia., 10” deep; rectangular (control valves), 10” x 14” x 15” deep.
    c. Sidewall Material: [PE.
    d. Cover Material: PE. Color to be green in turf areas and brown in planting areas.

        1) Lettering: "IRRIGATION."

B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minimum to 3 inches maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.

C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from [3/4 to 3 inches, to 18 inches below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

D. Provide minimum cover over top of underground piping according to the following:

1. Irrigation Main Piping: Minimum depth of 18 inches below finished grade.
2. Circuit Piping: 18 inches.
3. Drain Piping: 12 inches.
4. Sleeves: 18 inches below pavement.

3.2 PREPARATION

A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

3.3 PIPING INSTALLATION

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

E. Install fittings for changes in direction and branch connections.

F. Install unions adjacent to valves and to final connections to other components with NPS 2 (DN 50) or smaller pipe connection.

G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 (DN 65) or larger pipe connection.

H. Install underground thermoplastic piping according to ASTM D2774.

I. Install expansion loops in control-valve boxes for plastic piping.

J. Lay piping on solid subbase, uniformly sloped without humps or depressions.

K. Install ductile-iron piping according to AWWA C600.

L. Install PVC piping in dry weather when temperature is above 40 deg F (5 deg C). Allow joints to cure at least 24 hours at temperatures above 40 deg F (5 deg C) before testing.

M. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.

N. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

O. Install piping in sleeves under parking lots, roadways, and sidewalks.

P. Install sleeves made of Schedule 40 PVC pipe and socket fittings, and solvent-cemented joints.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.

F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.

G. Copper-Tubing Soldered Joints: Apply ASTM B813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.

H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

I. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

J. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number, ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
3. PVC Nonpressure Piping: Join according to ASTM D2855.

3.5 VALVE INSTALLATION

A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.

B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.

1. Install valves and PVC pipe with restrained, gasketed joints.

C. Aboveground Valves: Install as components of connected piping system.

D. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves.

E. Throttling Valves: Install in underground piping in boxes for automatic control valves.

F. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers at manufacturer's recommended heights.

C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.7 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install freestanding emitters on pipe riser to mounting height indicated.

B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.

C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.

D. Install drip tubes with direct-attached emitters on ground.

E. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.

F. Install off-ground supports of length required for indicated mounted height of device.

G. Install application pressure regulators in piping near device being protected, and in control-valve boxes.

H. Install vacuum relief valves in piping, in control-valve boxes.

3.8 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install control cable in same trench as irrigation piping and at least 2 inches below piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.9 CONNECTIONS

A. Comply with requirements for piping specified in Section 221113 "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

C. Connect wiring between controllers and automatic control valves.

3.10 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.

1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Perform all testing with University project managers and staff present in field.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Any irrigation product will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that controllers are installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.13 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.

3.14 CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.15 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.

3.16 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.

C. Underground irrigation main piping shall be:
1. Schedule 40, PVC pipe and socket fittings, and solvent-cemented joints.

D. Circuit piping shall be:
1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

E. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.

1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.

F. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

G. Drain piping shall be:
1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

3.17 VALVE SCHEDULE

A. Underground, Shutoff-Duty Valves: Use the following:

1. NPS 2 (DN 50) and Smaller: Curb valve, curb-valve casing, and shutoff rod.
2. NPS 3 (DN 80) and Larger: Iron gate valve, resilient seated; iron gate valve casing; and operating wrench(es).

B. Aboveground, Shutoff-Duty Valves:

1. NPS 2 (DN 50) and Smaller: Brass ball valve.
2. NPS 2-1/2 (DN 65) and Larger: Iron ball valve.

C. Throttling-Duty Valves:

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1. NPS 2 (DN 50) and Smaller: Brass ball valve.
2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Bronze automatic control valve.
3. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Iron ball valve.

D. Drain Valves:

1. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Brass ball valve.
2. NPS 1 to NPS 2 (DN 25 to DN 50): Brass ball valve.

END OF SECTION

SECTION 32 91 10

TOPSOIL AND SUBGRADE PREPARATION IN LANDSCAPE AREAS

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the necessary requirements for topsoil, topsoil characteristics, furnishing and placement of topsoil, and subgrade preparation in landscape areas.

1.2 RELATED SECTIONS AND DOCUMENTS

A. Drawings and general provisions of the Contract Documents including General, Supplemental, and Special Conditions, and Division 01 Specification Sections, apply to this Section.

B. Section 31 2000, Earth Moving

1.3 SUBMITTALS

A. Upon request from the Owner, provide a submittal containing the following items as a minimum for off-site topsoil material:

i. Borrow pit location.

ii. Soil classification.

iii. Permeability rate.

iv. pH.

v. Soil composition analysis.

1.4 QUALITY CONTROL / QUALITY ASSURANCE / TESTING

A. At the discretion of the Owner, topsoil shall be tested for physical properties, organic content, pH range, and nutrient content by a recognized soils lab to be selected by the Owner. All costs associated with the soil testing for topsoil shall be the responsibility of the Owner. The soils lab shall provide instructions on the proper method of taking soil samples, and shall determine the required rate of fertilizer and/ or lime application necessary to meet topsoil material requirements. The contractor is responsible for adhering to such requirements as recommended by the soils testing lab. The Contractor shall provide Owner a minimum of 48-hours' notice in advance of taking soil samples for proper coordination and observation by the Owner. Soil test(s) shall be submitted and approved by the Owner prior to any topsoil being transported to or placed on-site.

B. The acceptance of any subgrade areas within landscape areas shall be determined by the Owner and / or their representatives. No topsoil material shall be placed until the subgrade has been observed and approved by the Owner.

1.5 GENERAL NOTES FOR ALL LANDSCAPE AREAS SHALL BE AS FOLLOWS:

A. Topsoil material and subgrade preparations shall be performed during dry weather. The Contractor shall be responsible for coordinating with and providing advance notice to the Owner (twenty-four (24) hour minimum) for inspection and acceptance of subgrade in landscaping areas prior to placement of topsoil. Any topsoil placed prior to approval of subgrade by Owner shall be removed by the Contractor

at no additional costs to the Owner.

B. Any foreign materials shall be removed while spreading of topsoil.

C. There shall not be any rocks or debris greater than one (1) inch in greatest dimension.

D. Near existing trees, plants, sidewalks, curbs, concrete surfaces, fencing, walls, buildings, other hardscape or structures, topsoil shall be spread manually to prevent damage to such.

E. All topsoil shall be rolled in-place.

F. Fertilizer shall be applied at a rate required by topsoil analysis. Apply lime at a rate required to achieve a pH range between 5.0 and 7.0. Fertilizer and lime shall be thoroughly mixed into the upper two (2) inches of topsoil prior to rolling.

G. Topsoil shall be placed so that there is no potential for water to stand and/ or percolate behind curbs or pavement surfaces so that the integrity of the curb or paved surfaces are not negatively impacted by such.

PART 2 – PRODUCTS

2.1 LANDSCAPING AND TOPSOIL MATERIAL REQUIREMENTS

A. It is the Owner's intent and preference to segregate from other excavation, stockpile, and re-purpose existing topsoil on the project to be used as topsoil replacement.

i. If adequate space is available, the existing topsoil shall be stripped and stockpiled for re-use on the project. Otherwise, all topsoil shall be removed from the site.

ii. Topsoil shall be properly separated and protected from other earthen materials so that the topsoil does not become contaminated with other unacceptable materials.

iii. The Contractor shall neatly shape the topsoil in stockpiles in a manner that will mitigate erosion or loss of material. The stockpiles shall be covered with plastic for erosion control and from becoming overly saturated until ready for re-use.

B. In the event adequate quantity of topsoil is not stockpiled on-site, the Contractor shall provide topsoil meeting all the below requirements for topsoil material from an off-site source:

i. Topsoil material used shall be equivalent to Bama Sandy loam.

ii. Permeability rate for topsoil material shall be 0.60 to 6 inches per hour.

iii. Topsoil material shall have low shrink - swell potential.

iv. pH range shall be between 5.0 and 7.0.

v. Minimum organic matter of 2.0%.

C. Topsoil shall be free of viable noxious weed seed or vegetation propagules. The Contractor shall be responsible for applying necessary chemicals to the topsoil to rid material(s) of such weed seed or vegetation propagules.

PART 3 – EXECUTION

3.1 TOPSOIL REPLACEMENT AND SUBGRADE PREPARATION FOR ALL DISTURBED AREAS, AND LANDSCAPE, LAWN, GRASS AREAS

A. Prior to any construction, contractor shall investigate and document the condition of existing grades and if large concentrations of stone or deleterious material are present in any portion of the project area. Documentation shall include photographs and areas shall be indicated on plan prior to beginning any construction.

B. Contractor shall anticipate fine grading of all disturbed areas associated with the project. Any excess or spoil material shall be removed from the site. All costs associated with fine grading, additional embankment fill, or removal and disposal of excess material shall be incidental to the project.

C. All removal and disposal of temporary stones, one (1) inch or greater, for roadways, construction accesses, sidewalks, drives, construction, etc. shall be incidental to the project. It is the General Contractors' responsibility to fully remove, at no additional cost to the owner, these temporary materials as the project is completed. This applies to all materials, equipment, etc. the Contractor transports to the project. No such material shall be allowed to be wasted on site.

D. All prepared subgrades within the top six (6) inches of the trenches shall be 85% stone free. Subgrades that contain more than 15% stone in any 12" x 12" area shall be removed and replaced, by the Contractor at no additional costs to the Owner. Contractor to replace soil in such areas with acceptable subgrade material to be approved by the Owner's Representative.

E. After all excavation, concrete, curb, gutter, and sidewalks have been completed and at the direction of Owner's Representative, topsoil shall be replaced on excavated or disturbed areas as directed by the Owner's Representative to a minimum depth of four (4) inches.

F. Preparation of subgrade in areas mentioned in preceding paragraphs shall be as follows:

G. In areas that have not been altered or disturbed by excavation, grading, or stripping operations, prepare subgrade as follows:

   i. Till to a depth of not less than six (6) inches to a homogeneous mixture of fine texture, free of lumps, clods, or stones no larger than one (1) inch in greatest dimension.

   ii. Remove all foreign materials, including any and all extraneous materials such as lumps, clods, stone, roots, concrete, rubble, or any other debris from landscape area(s) in excess of one (1) inch in greatest dimension.
      a. Subgrade must be at least 85% soil.

   iii. Eliminate uneven areas and low spots so as to ensure proper positive drainage towards drainage areas and provide gradual grade change(s) of ground elevations. The Owner shall approve all subgrade fine grading prior to placement of topsoil.

   iv. Re-till soil to a homogeneous mixture of fine texture, free of lumps, clods, or stones larger than one (1) inch in greatest dimension, roots, and other extraneous material.

H. In all other areas, prepare subgrade as follows:

   i. Scarify subgrade to a depth of not less than six (6) inches.

   ii. Remove all foreign materials, including any and all extraneous materials such as lumps, clods, stone, roots, concrete, or rubble larger than one (1) inch in greatest dimension, or any other debris from landscape area(s).

   iii. Spread minimum of four (4) inches topsoil. Topsoil shall be placed in such a manner to ensure positive drainage towards drainage areas, inlets, etc.

I. All costs associated with grading of the site to accommodate topsoil placement, subgrade preparation, and actual topsoil placement (from off-site or on-site source), fine grading of such topsoil, removal and off-site disposal of all excess or unsuitable material, clean-up, removal of any and all stone, debris, etc., preparation of subgrade testing, or other items associated with such work shall be incidental to the project.

J. Any and all areas disturbed during construction shall be replaced to the original condition or better at no additional cost to the project. All grades, existing or proposed, shall be blended together in a seamless manner and grassed.

END OF SECTION 329110

SECTION 32 91 13

SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes planting soils specified by composition of the mixes.

B. Related Requirements:

1. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
3. Section 329300 "Plants" for placing planting soil for plantings.

1.3 ALLOWANCES

A. Preconstruction and field quality-control testing is part of testing and inspecting allowance.

1.4 UNIT PRICES

A. Work of this Section is affected by unit prices specified in Section 012200 "Unit Prices."

1.5 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.7 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include recommendations for application and use.
2. Include test data substantiating that products comply with requirements.
3. Include sieve analyses for aggregate materials.
4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:

    a. Manufacturer's qualified testing agency's certified analysis of standard products.
    b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.

c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Samples: For each bulk-supplied material, 1-quart (1-L) volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1.10 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil.

1. Notify Architect seven (7) days in advance of the dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.11 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by Contractor in presence of Landscape Architect or Owner under the direction of the testing agency.

1. Number and Location of Samples: Minimum of eight representative soil samples where directed by Landscape Architect for each soil to be used or amended for landscaping purposes.

2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils."
3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.12 TESTING REQUIREMENTS

A. Topsoil shall be tested for physical properties, organic content, pH and nutrient content by a recognized soils lab selected by the Manager of Landscape and Grounds Maintenance. The soils lab shall provide instructions on the proper method of taking soil samples. Contact the Owner before taking soil samples so that the process may be observed for accuracy of sampling technique. The mechanical analysis of the soil shall be as follows:

Sieve Size	**Percent Passing**
1" Mesh	99 - 100 percent
1/4" Mesh	97 - 99 percent
No. 100 Mesh	40 - 60 percent
No. 200 Mesh	20 - 40 percent

B. Soil Test shall be submitted to and approved by Campus Landscape Architect prior to any topsoil being transported or placed on the University of Alabama campus.

C. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 PLANTING SOILS SPECIFIED BY COMPOSITION

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Planting-Soil Type: Existing, on-site surface soil, with the duff layer, if any, retained and stockpiled on-site; modified to produce viable planting soil. Blend existing, on-site surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

C. Planting-Soil Type: Imported, naturally formed soil from off-site sources and consisting of sandy loam according to USDA textures; and modified to produce viable planting soil.

1. Topsoil used in all landscape work, for the University of Alabama, shall be equivalent to Bama sandy loam, and processing characteristics of representative soils in the project vicinity that produce heavy growths of crops, grass, or other vegetation. Topsoil shall have a permeability rate of .6-6 inches per hour, low shrink-swell potential, pH 5.0-7.0, minimum two percent (2%) organic matter. Topsoil shall not be handled in a frozen or muddy condition. Soil shall be free of subsoil, brush, organic litter, or objectionable weeds, clay, clots, stumps, stones, roots, and debris one (1) inch or larger, or any other material harmful to plant growth or hindrance to planting or maintenance operations. Soils are to be free of noxious weed seed or vegetation propagules. Should regenerative materials be present in the soil, Contractor shall eradicate and remove such growth, both surface and root, which may appear in the imported materials within one (1) year following acceptance of work.

2.2 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Form: Provide lime in form of ground dolomitic limestone.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through a No. 40 (0.425-mm) sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 (0.30-mm) sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33/C33M.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:

1. Feedstock: Limited to leaves.
2. Reaction: pH of 5.5 to 8.
3. Soluble-Salt Concentration: Less than 4 dS/m.
4. Moisture Content: 35 to 55 percent by weight.
5. Organic-Matter Content: 30 to 40 percent of dry weight.
6. Particle Size: Minimum of 98 percent passing through a 1/2-inch sieve.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch (13-mm) sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum **5** dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a 1/2-inch (13-mm) sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. (2.4 kg/cu. m) of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. (4 kg/cu. m) of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 FERTILIZERS

A. Fertilize per recommendations from the soil test provided by a reputable testing lab.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches (150 mm) and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 2-inch (50-mm) sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 8 inches (200 mm). Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 2 inches (50 mm) of subgrade. Spread remainder of planting soil.

C. Mixing: Spread unamended soil to total depth of 6 inches (150 mm), but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

   a. Mix lime and sulfur with dry soil before mixing fertilizer.
   b. Mix fertilizer with planting soil no more than seven (7) days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches (200 mm) in loose depth for material compacted by compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 and tested in-place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: Apply 4 inches (100 mm) of compost to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections with the Owner present.

3.6 PROTECTION

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is over-compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by the Landscape Architect and replace contaminated planting soil with new planting soil.

3.7 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION

SECTION 32 92 00

TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sodding.
2. Erosion-control materials.

B. Related Requirements:

1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified landscape Installer.

B. Product Certificates: For fertilizers, from manufacturer.

C. Material Test Reports: For existing surface soil and imported topsoil.

D. Planting Schedule: Indicating anticipated planting dates for each type of planting.

E. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures per the University of Alabama's standard maintenance practices.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turfgrass establishment, and experience on landscape work with budgets of $200,000.00 or more. Submit a letter stating such experience.

1. Experience: Installer certified in the State of Alabama and with a minimum of five years experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
3. Pesticide Applicator: State licensed, commercial.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

1.9 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: No earlier than April
2. Fall Planting: No later than September

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 TURFGRASS SOD

A. Turfgrass Sod: Approved, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Turfgrass Species, Warm-Season Grass: Empire Zoysia (Zoysia japonica ‘Empire’)

2.2 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

E. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

F. Asphalt Emulsion: ASTM D977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.3 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions

and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.4 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd. (0.5 kg/sq. m), with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

C. Erosion-Control Mats: Cellular, nonbiodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface. Include manufacturer's recommended anchorage system for slope conditions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Landscape Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."

B. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

C. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Where lawns are to be established in areas that have not been altered or disturbed by excavation, grading, or stripping operations, prepare the soil as follows:

1. Till to a depth of not less than 6 inches.
2. Remove foreign materials.
3. Eliminate uneven areas and low spots. Make changes in grade gradual.
4. Till soil to a homogenous mixture of fine texture, free of lumps, clods ore stones larger than 2 inches in greatest dimension, roots, and other extraneous material.

E. Prepare sub-grade for lawn in other areas as follows:

1. Scarify soil to a depth of not less than 4".
2. Remove foreign materials.
3. Spread 4 inches minimum topsoil at seeded areas.

F. Place topsoil during dry weather.

G. Remove foreign materials while spreading.

H. Near plants and buildings, spread topsoil manually to prevent damage.

I. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of sub-grade.

J. Roll placed topsoil. After completion of sodding, turf grass shall have a smooth surface free of depressions or bumps.

K. Apply fertilizer at rate required by topsoil analysis. Apply lime at rate required to achieve ph range between 6.0 and 6.5. Mix thoroughly into upper 2 inches of topsoil.

3.4 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth

surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across slopes exceeding 1:3.
2. Anchor sod on slopes where grade is 4 inches per foot or greater, secure with wood pegs spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.5 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep lawn uniformly moist.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water lawn with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow Zoysia grass (Zoysia japonica ‘Empire’) to a height of 3/4 to 1 1/4 inch.

D. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry or per the University of Alabama's standard fertilization practices.

3.6 SATISFACTORY LAWNS

A. Turf installations shall meet the following criteria as determined by the Landscape Architect:

1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.7 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by lawn work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Keep all planting areas neat, weeded, and uniformly mulched on a continuous basis. Clean up adjacent walks and pavement where lettered as a result of maintenance operations, on a continuous basis.

E. Remove nondegradable erosion-control measures after grass establishment period.

3.8 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. Sodded Turf: 30 days from date of Substantial Completion.

END OF SECTION

SECTION 32 93 00

PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Plants.
2. Tree stabilization.
3. Tree-watering devices.
4. Landscape edgings.
5. Tree grates.

B. Related Sections:

1. Section 01 56 39 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Section 32 92 00 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices specified in Section 01 22 00 "Unit Prices."

B. Unit prices apply to authorized work covered by quantity allowances.

C. Unit prices apply to additions to and deletions from the Work as authorized by Change Orders.

1.4 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

D. Finish Grade: Elevation of finished surface of planting soil.

E. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

F. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

G. Planting Area: Areas to be planted as indicated on the Landscape Plan in the Drawings.

H. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation" for drawing designations for planting soils.

I. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

K. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

L. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.5 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.7 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.

B. Samples for Verification: For each of the following:

1. Before ordering or purchasing materials, provide samples of those materials to Landscape Architect for approval, if so requested.
2. Submit certification tags from trees, shrubs, sod, and seed verifying type and purity.
3. Unless otherwise authorized notify Landscape Architect at least 72 hours in advance of anticipated delivery of plant materials. Legible copy of invoice, showing kinds and sizes of materials included for each shipment, shall be furnished to the Owner.
4. Inform Owner and Landscape Architect of date when planting shall commence.

1.8 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.

B. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

C. Sample Warranty: For special warranty.

1.9 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures per the University of Alabama's standard maintenance requirements.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.

1. Experience: State certified installer with a minimum of five (5) years experience in landscape installation in addition to requirements in Section 01 40 00 "Quality Requirements."
2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
3. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-

grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches (150 mm) above the root flare for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the root flare for larger sizes.

2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Landscape Architect of sources of planting materials seven (7) days in advance of delivery to site.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.

F. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

G. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

H. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
2. Do not remove container-grown stock from containers before time of planting.
3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.12 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.13 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
   b. Structural failures including plantings falling or blowing over.
   c. Faulty performance of tree stabilization, edgings, and tree grates.
   d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods: From date of Substantial Completion.

   a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
   b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sunscald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots are unacceptable.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

F. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud or just starting to bloom.

2.2 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Wood and bark chips to match University of Alabama standards.
2. Size Range: 3 inches (76 mm) maximum, 1/2 inch (13 mm) minimum
3. Color: To match University of Alabama standards.

2.3 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions

and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.4 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. See tree planting detail in the Drawings.

2.5 TREE GRATES

A. See tree grate detail on Drawings.

2.6 MISCELLANEOUS PRODUCTS

A. Wood Pressure-Preservative Treatment: AWPA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.

B. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

C. Burlap: Non-synthetic, biodegradable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Landscape Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

D. Lay out plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 13 "Soil Preparation."

B. Placing Planting Soil: Place planting soil over exposed subgrade.

C. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. See planting details in the Drawings for tree and shrub planting methods.
2. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
3. Maintain supervision of excavations during working hours.
4. All excavations to remain supervised during work hours. No excavations to remain open after work hours.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil and mixed with new topsoil at a 50/50 rate unless otherwise indicated unless existing subsoil and topsoil is deemed unsuitable for use. Notify Landscape Architect to verify if in question.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs. If excavation holds water or does not percolate out within two (2) hours, notify Landscape Architect.

3.5 TREE, SHRUB, AND GROUNDCOVER PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: See tree planting detail in the Drawings for planting information.

D. Container-Grown Stock: See tree, shrub and groundcover planting details in the Drawings for planting information.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball. See detail in the Drawings for planting information.

3.6 TREE AND SHRUB PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and shrubs as directed by Landscape Architect.

C. Prune, thin, and shape trees and shrubs according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Landscape Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do <u>not</u> apply pruning paint to wounds.

3.7 TREE STABILIZATION

A. See tree planting detail in the Drawings for tree stabilization information.

3.8 GROUND COVER AND PLANT PLANTING

A. See groundcover planting detail in the Drawings for planting information.

B. Set out and space ground cover and plants other than trees, shrubs, and groundcovers as indicated on Drawings in even rows with triangular spacing.

C. Use planting soil for backfill.

D. Dig holes large enough to allow spreading of roots.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.9 PLANTING AREA MULCHING

A. See tree, shrub, and groundcover plant details in the Drawings for mulching methods and required depth.

3.10 EDGING

A. See detail in Drawings for trench edging along planting beds.

3.11 INSTALLATION OF TREE GRATES

A. Tree Grates: Install according to manufacturer's written instructions. Set grate segments flush with adjoining surfaces. Shim from supporting substrate with soil-resistant plastic. Maintain a 3-inch-minimum growth radius around base of tree; break away portions of casting, if necessary, according to manufacturer's written instructions.

3.12 IRRIGATION

A. See Drawings for Irrigation Plan and Details.

3.13 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.14 PESTICIDE APPLICATION

A. Per the University of Alabama's standard maintenance requirements for pesticide application.

3.15 MAINTENANCE SERVICE

A. Watering: See Irrigation Plan, Details, and Notes for irrigation system information.

B. Weeding: Landscape maintenance contractor shall keep areas free from weeds and undesirable grasses by approved methods and materials.

C. Disease and insect pest control: Inspect plant material at least once each month to locate any disease or insect pest infestations. Upon discovery of infestation, nature or species of infestation shall be identified. Control in accordance with industry standards shall be immediately implemented.

D. Fertilizing: Landscape maintenance contractor is to fertilize on regularly scheduled program as is required by the University of Alabama to fit requirements of plant material to maintain vigorous, healthy growth.

E. Pruning and repair: Amount of pruning shall be limited to minimum necessary to remove dead or injured branches, to compensate for loss of roots as result of transplanting operations, and to maintain safety in traveled areas. Pruning shall be done to not change the natural habit or shape of plant. Cuts shall be made flush, leaving no stubs.

F. Mowing: Mow grass areas at regular intervals to keep grass height from exceeding 3-inches. Mow in such manner as to prevent clippings from blowing onto paved areas and sidewalks. Cleanup after mowing shall include sweeping or blowing to clear mowing debris.

G. Clean up: During course of maintenance, excess and waste materials shall be continuously and promptly removed at end of each workday.

H. Maintenance report and schedule of activities: Per the University of Alabama's normal maintenance requirements.

END OF SECTION 32 93 00

SECTION 32 93 01
TREE PROTECTION

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the following:

i. Tree protection requirements.

ii. Installation of tree protection elements.

1.2 RELATED SECTIONS

A. Section 31 1000 – Site Clearing

B. Section 02 4116 – Site Demolition

1.3 DEFINITIONS

A. Root Protection Zone - Area extending from the edge of the protected tree trunk 1.5' per every 1" of tree diameter at breast height measured 4.5' from the ground. Example: 10" Oak Root Protection Zone = 10" x 1.5 = 15' radius from edge of trunk.

B. Root Protection Zone Barrier - Minimum 4' chain-link fence supported by 2" diameter post driven 2' into the ground with one 3' wide gate for maintenance. Fence shall have an 8 ½" by 11" sign which reads "Root Protection Zone, Do Not Disturb". Enclosed area shall also be covered by 4" of pine bark mulch.

C. Drip Line – Outer perimeter of branches of any plant

D. Alternatives - Prearranged variations of work within the Root Protection Zone discussed during required Preconstruction Tree Protection Meeting. These alternatives will allow for flexibility of specific requirements which arise during construction and will be considered on a case-by-case basis.

1.4 PAYMENTS

A. Payment for all associated items of work shall be as per the Unit Price Schedule. If a specific pay item(s) is not identified, the work shall be incidental to the project.

PART 2 – PRODUCTS

2.1 FENCING

A. Tree protection fencing shall be galvanized chain link fence that measures a minimum of six feet high. The fence shall be secured using steel posts that are the same height as the fence. Steel posts shall be driven no less than two feet in the ground and be spaced no further than 10 feet apart.

PART 3 – EXECUTION

3.1 SUMMARY

A. Tree protection barriers shall be installed prior to the start of any site activity and shall remain in effective condition until start of landscape construction in the immediate area of the project.

3.2 SCOPE

A. Performed by Contractor: Install fencing, gate access, and signage per paragraph 1.3.B around the

Root Protection Zone.

B. Performed by Contractor: Install mulch in Root Protection Zone per paragraph 1.3.B.

C. Maintenance of the Root Protection Zone.

3.3 GENERAL PROCEDURES

A. The following activities shall not be allowed within the Root Protection Zone after barriers have been erected:

i. Breaking of branches, scraping of bark or unauthorized cutting.

ii. Nailing or bolting.

iii. Using trees as anchorage or using trees as temporary support in any way (including cabling around any part of the tree).

iv. Unauthorized filling, excavating, trenching, or auguring within protected root zone.

v. Compaction of protected root zone by vehicles, equipment or pedestrians.

vi. Storage of any materials.

vii. Dumping of construction waste or materials within the protected root zone.

viii. Disposal of liquid waste, concrete sleuth, gas, oil, paint, or any other contaminants, which may impact the protected root zones.

ix. Removal of tree protection barricades or construction fencing prior to completion of project.

B. Required Maintenance of the Root Protection Zone will include:

i. **Performed by The UA** - Provide 2" of water over the Root Protection Zone through the duration of construction. Water shall be provided every two weeks (June-October) and once a month (Nov-April).

ii. **Performed by the Contractor** - Any roots or branches that extend beyond the Root Protection Zone which require pruning must be pruned by a qualified Arborist or other tree professional as approved by the UA Landscape Architect. All pruning of tree roots and branches must be in accordance with good arboricultural standards. Roots located outside the Root Protection Zone that are to be pruned must first be exposed by hand digging or by using a low-pressure hydro-vac method. This will allow a proper pruning cut and minimize tearing of the roots from equipment.

iii. **Performed by The UA** - The root zones will require up to 4 annual applications of deep root aeration and fertilization depending on the length of the project. One application will be made at the beginning of construction. The second application will be made during construction. The third application will be made at the completion of construction. The fourth application will be made prior to the one-year closeout. Actual aeration to be performed by UA Facilities and Grounds or other entity as specified by UA, but Contractor required to provide access and coordinate, as necessary.

C. The Contractor shall contact the UA Field Coordinator if any portion of the Root Protection Zone has been compromised.

3.4 COORDINATION

A. The project arborist will coordinate with other trades and contractors affecting or affected by work of this section to ensure that tree protection measures are understood prior to work commencing.

B. An on-site review of tree protection measures will be completed among the designer, Landscape Architect, Contractor, and UA Project Manager prior to any site work or grading is started.

C. During this meeting, the pre-construction evaluation of those trees identified to remain shall be completed.

D. The Contractor is responsible for maintaining all tree protection measures during all construction phases of the project.

E. The project arborist and UA Project Manager and FS Landscape Manager or designee shall be contacted immediately if any of the trees on site are damaged during the construction of the project. The project arborist in consultation with the UA Project Manager and FS Landscape Manager or designee will assess the damage to any tree and provide corrective measures, which may include pruning, tree wound repair, or even removal.

F. Upon completion of the project the project arborist will contact the UA Project Manager and review the post construction evaluation of the trees on the site.

G. No tree shall be removed from the site without the completion of a tree condition report and prior notification and approval of the UA Project Manager.

H. Tree removal within the UA National Historic District requires a Historic Tree Checklist to ensure that any trees being removed are not considered historic. An arborist report must accompany the Historic Tree Checklist.

3.5 INSPECTIONS AND FINES

A. Throughout the duration of construction there will be on-going maintenance by UA Facilities and Grounds and unscheduled site inspections by UA Landscape Architect of the Root Protection Zones. Contractor is required to provide access and coordinate these activities, as necessary. The Landscape Architect will notify the UA Field Coordinator and Contractor of any damages to the trees or deficiencies cited immediately.

B. Violations and damages will be handled in accordance with The UA guidelines. Hazardous conditions such as ice, flooding, and pollution when using water shall be avoided or mitigated.

C. Damage to campus trees will include any of the prohibited practices listed above and will be determined by the UA Landscape Architect. The Project Manager will be notified by the UA Landscape Architect of the damage assessment and will issue a deductive change order to contract for the amount of damages. The value of tree damage will be assessed, and fines levied up to 100% of the value listed below:

1" - 3" caliper:	$200/inch
3" - 6" DBH:	$300/inch
6" - 9" DBH:	$400/inch
9" - 12" DBH:	$500/inch
12" - 15" DBH:	$600/inch
15" DBH or more:	$700/inch

D. The Certificate of Substantial Completion will not be issued until after a final tree inspection by Project Manager, UA Landscape Architect, and Contractor.

END OF SECTION 329301

SECTION 33 24 33
REINFORCED CONCRETE PIPE

PART 1 – GENERAL

1.1 SUMMARY:

A. This section of specifications covers the material and installation requirements for reinforced concrete pipe.

1.2 RELATED SECTIONS:

A. Section 31 2100 – Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2605 – Precast Concrete Manholes

1.3 REFERENCES

A. ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

B. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

C. ASTM C506 – Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe.

D. Alabama Department of Transportation (ALDOT) Standard Specifications for Highway Construction, Latest Edition.

1.4 QUALITY ASSURANCE

A. All piping and appurtenances installed by the Contractor shall be new, unused and shall be delivered directly to the job site from the Manufacturer.

B. Each joint of pipe shall be plainly marked at the site of manufacturer to indicate the class of reinforcement and the wall thickness designation.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Reinforced concrete pipe shall be of the Class (III, IV, or V) and size as designated on the construction plans and shall be manufactured using minimum 4,000 psi concrete.

B. Round concrete pipe shall be tested under and comply with ASTM Specification C76.

C. Arch pipe shall be tested under and comply with ASTM Specification C506.

D. Joints shall be tested under and comply with ASTM Specification C443.

PART 3 – EXECUTION

3.1 EXAMINATION:

A. The contractor shall examine the site, trench and surrounding conditions to assure proper installation of the pipe.

B. The contractor shall examine all pipe sections and appurtenances for any physical damage prior to its

installation.

C. Trenches shall be inspected for proper alignment and grade. Check trench bottom to assure proper clearance from other utilities, pipelines or existing structures.

D. Any bedding required by the drawings or specifications shall be installed prior to pipe placement.

3.2 INSTALLATION:

A. Pipe installation shall be according to this section of the specification and the manufacturer's instructions and/or referenced specifications.

B. Rubber ring gasket joints for concrete sewer pipe shall be installed according to the pipe manufacturer's specifications and recommendations. Extreme care shall be used in joining pipe to avoid damaging the rubber ring or displacing it from the proper operating position.

C. The inside of all bells and outside of all spigots shall be wiped to remove all dirt, water, or other foreign matter so that their surfaces are clean and dry when pipes are joined.

3.3 JOINTS

A. Joints shall be sealed with a butyl rubber sealant around the full perimeter of the pipe joint, placed along the outside of the spigot end of the joint near the tip. The minimum gasket width shall be two (2) inches, and be installed with a minimum of 50% compression so that the sealant completely seals the pipe joint. The maximum point joint gap shall be 1/2 inch once the pipe is belled up and pressed together against the butyl rubber sealant. The butyl rubber sealant shall be ConSeal CS-202 butyl rubber sealant, or approved equal. Any joints not properly sealed which experience visible air gaps or leakage from the surrounding soil shall be sealed with ConSeal CSR-1100 or approved equal water activated polyurethane foam sealant.

B. All lift holes in concrete pipe shall be properly sealed in order to prevent seepage of water or backfill from the surrounding subgrade into the pipe. Lift holes shall be plugged with polymer plastic plugs made by POPIT, Inc. or approved equal. Lift hole plugs shall be compressed flush with the outside face of the concrete pipe, and then be completely sealed with a minimum 12" by 12" section of polyolefin backed exterior joint wrap material with a minimum thickness of 0.065". Joint wrap material shall be ConSeal CS-212 joint wrap or approved equal. Any lift holes not properly sealed which experience visible air gaps or leakage from the surrounding soil shall be sealed with ConSeal CSR-1100 or approved equal water activated polyurethane foam sealant.

3.4 BACKFILLING:

A. Trenches shall be backfilled according to Section 31 2100.

END OF SECTION 332433

SECTION 33 24 34

POLYPROPYLENE STORM SEWER PIPE

PART 1 – GENERAL

1.1 SUMMARY:

A. This section of specifications covers the material and installation requirements for polypropylene pipe for use in gravity-flow storm drainage applications.

1.2 RELATED SECTIONS:

A. Section 31 2100 – Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2605 – Precast Concrete Manholes

1.3 REFERENCES

A. AASTO M330 – Standard Specification for Polypropylene Pipe (12 to 60 in. Diameter) ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

B. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

C. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

D. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

E. ASTM F1417 – Standard Practice for Installation Acceptance of Plastic Non-Pressure Sewer Lines Using Low-Pressure Air.

F. ASTM F2487 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High-Density Polyethylene and Polypropylene Pipelines.

G. ASTM F2881 – Standard Specification for 12 to 60 in. Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications.

H. Alabama Department of Transportation (ALDOT) Standard Specifications for Highway Construction, Latest Edition.

1.4 QUALITY ASSURANCE

A. All piping and appurtenances installed by the Contractor shall be new, unused and shall be delivered directly to the job site from the manufacturer.

B. Pipe shall be handled, transported, delivered, and stored by methods that will not damage the pipe. Any pipe damaged or bent will be rejected and shall be replaced by the Contractor at no additional cost to the project.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Polypropylene Pipe shall be dual-wall construction with a smooth interior (minimum Manning's "n" value of 0.012) and annular exterior corrugations. All pipes shall meet or exceed ASTM F2881 or

AASHTO M330.

i. Polypropylene compound for pipe and fitting production shall be impact modified copolymer meeting the material requirements of ASTM F2881, Section 5 and AASHTO M330, Section 6.1.

ii. Pipe shall be joined using a bell and spigot joint meeting the requirements of ASTM F2881 or AASHTO M330. The joint shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477. Gasket shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly. All pipe shall have an exterior bell wrap installed by the manufacturer.

iii. To assure water tightness, field performance verification shall be accomplished by testing in accordance with ASTM F1417 or ASTM F2487, with leakage rates as recommended by the pipe manufacturer.

iv. Fittings shall conform to ASTM F2881 or AASHTO M330. Bell and spigot connections shall utilize a welded or integral bell and valley or inline gaskets meeting the watertight joint performance requirements of ASTM D3212.

PART 3 – EXECUTION

3.1 EXAMINATION:

A. The contractor shall examine the site, trench and surrounding conditions to assure proper installation of the pipe.

B. The contractor shall examine all pipe sections and appurtenances for any physical damage prior to its installation.

C. Trenches shall be inspected for proper alignment and grade. Check trench bottom to assure proper clearance from other utilities, pipelines or existing structures.

D. Any bedding required by the drawings or specifications shall be installed prior to pipe placement.

3.2 INSTALLATION:

A. Pipe installation shall be according to this section of the specification, the manufacturer's instructions and/or referenced specifications, and in accordance with ASTM D3212.

B. Pipe connection to concrete structures (manholes, headwalls, etc.) shall be made with flexible boot connections, i.e., KOR-N-SEAL boots or approved equal.

C. The inside of all bells and outside of all spigots shall be wiped to remove all dirt, water, or other foreign matter so that their surfaces are clean and dry when pipes are joined.

D. Polypropylene pipe shall be tested for excessive deformation. The test shall be performed by the Contractor in the presence of the Owner's representative. Testing shall be conducted no fewer than 30 days after the completion of the compaction of all fill over the pipe and prior to any asphalt/concrete placement. The Contractor shall conduct the test by pulling a nine-point mandrel through the entire length of the pipe by hand. The mandrel shall meet the following requirements:

i. It shall be made of steel or aluminum.

ii. It shall have an effective diameter of 95% of the nominal inside diameter of the pipe.

iii. It shall be at least as long as the diameter of the pipe.

iv. It shall be fitted with pulling rings at each end.

v. It shall be stamped or engraved on some segment other than a runner with the pipe size and mandrel outside diameter.

Pipe and installation shall be unacceptable if the mandrel cannot be pulled through the pipe by hand without damaging the pipe. All pipe failing the mandrel test as determined by the Owner's representative, shall be replaced by the Contractor at no additional cost to the project.

3.3 BACKFILLING

A. Trenches shall be backfilled according to Section 31 2100.

END OF SECTION 332434

SECTION 33 26 00
DUCTILE IRON PIPE AND FITTINGS

PART 1 – GENERAL

1.1 SUMMARY

A. This section of specifications covers the material and installation requirements for ductile iron pipe and fittings.

B. The testing requirements for materials, in-place, specified under this section shall conform to Section 2660 – Water System.

1.2 RELATED SECTIONS

A. Section 31 2100 – Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2660 – Water System

1.3 REFERENCES

A. ANSI/AWWA C104/A21.4 – American National Standard for Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.

B. ANSI/AWWA C105/A21.5 – American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.

C. ANSI/AWWA C110/A21.10 – American National Standard for Ductile-Iron and Gray-Iron Fittings, 3-in. through 48-in., for water and other liquids.

D. ANSI/AWWA C111/A21.11 – American National Standards for Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.

E. ANSI/AWWA C115/A21.15 – American National Standard for Flanged Ductile-Iron Pipe with Ductile-Iron of Gray-Iron Threaded Flanges

F. ANSI/AWWA C150/A21.50 – American National Standard for the Thickness Design of Ductile-Iron Pipe.

G. ANSI/AWWA C151/A21.51 – American National Standard for Ductile-Iron Pipe, Centrifugally Cast for Water and Other Liquids.

H. ANSI/AWWA C153/A21.53 – American National Standard for Ductile-Iron Compact Fittings for Water Service.

I. AWWA C600 – Installation of Ductile Iron Water Mains and Their Appurtenances.

1.4 QUALITY ASSURANCE

A. All piping, fittings, and appurtenances installed by the Contractor shall be new and unused and shall be suitable for the intended purposes.

B. Each joint of pipe shall be plainly marked at the site of manufacturer to indicate the class, thickness, and/or strength.

1.5 DELIVERY, STORAGE, HANDLING

A. All ductile iron pipe and fittings are subject to inspection at delivery and other times as deemed

necessary by the Engineer. Any pipe and/or fittings damaged during delivery shall be promptly removed from the job site.

B. Ductile-iron pipe shall be stored off the ground supported by timbers, railings or concrete supports and shall be of sufficient size to avoid contact with the ground or adjacent piping. Supports shall have chocks to prevent movement. Stacking shall be low enough to provide a safe condition, especially in neighborhoods and accessible areas.

C. Pipe and fittings shall be stored to prevent damage to the interior or exterior lining. The interior of all pipe and fittings shall be kept free of dirt and debris. Ductile iron pipe shall not be stacked higher than specified in Table 1 of AWWA C600.

D. Pipe and fittings shall be loaded and unloaded by hoists or skids to avoid sudden impact to the material. In no case shall the pipe or fittings be dropped. Slings, hooks, or pipe tongs shall be padded to avoid damage to the exterior or interior linings.

E. Gaskets for mechanical joint and push-on joint pipe and fittings shall be stored in a cool dry place out of direct sunlight. Contact with petroleum-based substances is prohibited.

PART 2 – PRODUCTS

2.1 APPROVED PIPE MANUFACTURERS:

A. American Cast Iron Pipe Company

B. U.S. Pipe

C. Others as approved by the Owner's Representative

2.2 APPROVED FITTING MANUFACTURES:

A. American Cast Iron Pipe Company

B. U.S. Pipe

C. Mueller

D. Clow

E. Others as approved by the Owner's Representative

2.3 DUCTILE IRON PIPE AND FITTINGS SHALL CONFORM TO THE FOLLOWING:

A. Pipe and Fittings

i. In general, ductile iron pipe for underground work shall have push-on or mechanical joints; ductile iron pipe for exposed work shall have flanged joints. Where shown on the drawings, grooved-end pipe shall be used to allow removal of valves and fittings.

ii. Ductile iron pipe with push-on or mechanical joints shall conform to ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51, latest revision. Push-on or mechanical joints shall conform to the requirements of ANSI/AWWA C111/A21.11.

iii. Pipe classes shall be based on wall thicknesses in accordance with bury depths and laying conditions as specified in C150/A21.50 and C151/A21.51. Unless otherwise shown differently on the Drawings or in the Bid Schedule minimum pipe requirements are as follows:

a. For buried water pipe four (4) inches in diameter through twelve (12) inches in diameter shall

be Class 52 pipe. For pipe fourteen (14) inches in diameter and larger shall be Class 50.

iv. Ductile iron pipe with flanged or grooved joints shall conform to the requirements of ANSI/AWWA C115/A21.15. Flanges for threading onto ductile iron pipe shall conform to the requirements of ANSI/AWWA C115/A21.15.

v. Fittings for ductile iron pipe with push-on or mechanical joints shall conform to the requirements of ANSI/AWWA C110/A21.10 and shall have a minimum pressure rating of 350 psi for sizes ≤ 24 inches, and a pressure rating of 250 psi for sizes ≥ 30 inches. Ductile iron fittings for ductile iron pipe with push-on or mechanical joints may be compact fittings conforming to ANSI/AWWA C153/A21.53. Joints shall be mechanical joints conforming to the requirements of ANSI/AWWA C111/A21.11.

vi. Fittings for flanged ductile iron pipe shall conform to the requirements of ANSI/AWWA C110/A21.10 (including appendix) and shall have a minimum pressure rating of 250 psi. Fitting flanges shall conform to the requirements of ANSI/AWWA C110/A21.10. Gaskets for flanged joints shall be full face of first quality red rubber, minimum 1/8-inch thick.

B. Coatings and Linings:

i. Exposed piping shall have exterior rust inhibitive primer coating compatible with finished paint.

ii. All ductile iron pipe and fittings for underground installation shall receive an exterior bituminous coating of 1-mil minimum thickness.

iii. All ductile iron pipe and fittings shall have an interior cement-mortar lining with asphaltic seal coat in accordance with ANSI/AWWA C104/A21.4.

iv. Where indicated on the drawings or required by the City / Owner's Representative, ductile iron pipe and fittings situated in aggressive soils shall be polyethylene wrapped in accordance with ANSI/AWWA C105/A21.5. Wrappings shall be 8-mil low density or 4-mil high density, cross-laminated (HDCL) polyethylene film.

PART 3 – EXECUTION

3.1 EXAMINATION

A. The contractor shall examine the site, trench and surrounding conditions to assure proper installation of the pipe and associated fittings.

B. The contractor shall examine pipe and fittings for any scratches or abrasions to the coating or linings, or other physical damage prior to its installation.

C. Trenches shall be inspected for proper alignment and grade. Check trench bottom to assure proper clearance from other utilities, pipelines or existing structures.

D. Any bedding required by the drawings or specifications shall be installed prior to pipe placement.

3.2 INSTALLATION

A. Pipe installation shall be according to this section of the specification and the manufacturer's instructions and/or referenced specifications.

B. Every care shall be taken in the handling, cutting, and laying of pipe and fittings to avoid damaging the interior or exterior coating. Damaged or defective areas shall be repaired or replaced to the satisfaction

of the Engineer.

C. Any ductile iron fitting showing a crack, any fitting or pipe which has received a severe blow that may have caused an incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the job site. In any pipe showing a distinct crack and in which it is believed there is no incipient fracture beyond the limits of the visible crack, the cracked portion, if so approved, may be cut off by and at the expense of the Contractor before the pipe is laid so that the pipe used may be perfectly sound. The cut shall be made in the sound barrel at a point at least 12 inches from the visible limits of the crack. Except as otherwise approved, all cutting shall be done with a machine having rolling wheel cutters or knives adapted to the purpose. All cut ends shall be beveled and shall be examined for possible cracks caused by cutting. Special care shall be taken to avoid excessive heat during cutting which might damage pipe lining.

D. Each section of ductile iron pipe shall be placed in the prepared trench with the full length of the barrel resting upon the pipe bed and with the pipe bell over a bell hole excavated at the proper location to accommodate the bell. No temporary supports under the pipe such as bricks, rocks, etc., shall be permitted.

E. Any pipe found defective shall be replaced. Cracked pipe may be cut as specified previously in this section if authorized by the Engineer.

F. Pipeline shall be laid with bells in direction of laying unless it is necessary to do otherwise to make connections to existing pipe. Where pipe is to be laid on a slope, the direction of laying shall be from downstream to upstream.

G. All lumps, blisters, and excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped clean and dry and be free from dirt, sand, grit, or any foreign material before the pipe is laid. Foreign material shall be prevented from entering the pipe while it is being placed in the trench. During laying operations, no debris, tools, clothing, or other materials shall be placed in the pipe.

H. As each length of pipe is placed in the trench, the joint shall be assembled, and the pipe brought to correct line and grade as shown on the drawings.

I. Assembly of ductile iron push-on joints and mechanical joints shall be in accordance with AWWA Specifications C600, Section 3.4. The contractor shall use particular care in cleaning the socket, plain end and gasket. Mechanical joint bolts shall be tightened to the proper torques shown in Table 4, AWWA Standard C600.

J. Deflections of ductile iron pipe having mechanical joints, if authorized by the Engineer, shall not exceed the deflection limits shown in Table 6, AWWA Standard C600. All bolts and set screws shall be checked immediately before backfilling.

K. Deflections for push-on joint pipe shall conform to Table 5 of AWWA C600.

L. At times when pipe laying is not in progress, the open ends of pipe shall be closed by the use of pipe plugs or other methods approved by the Engineer to keep mud, water, and other debris out of the pipe.

M. Pipe cutting for the insertion of valves and fittings shall follow the manufacturer's recommendations. No torch cutting shall be allowed. Interior and exterior coatings shall be repaired and touched-up per manufacturer’s recommendations.

N. Trenches shall be backfilled according to Section 31 2100.

END OF SECTION 332600

SECTION 33 26 01

HIGH-DENSITY POLYETHYLENE PIPE AND FITTINGS

PART 1 – GENERAL

1.1 SUMMARY

A. This section of specifications covers the material and installation requirements for high-density polyethylene (HDPE) water pipe and fittings.

B. The testing requirements for materials, in-place, shall be as specified in Section 33 2660, Water System.

1.2 RELATED SECTIONS:

A. Section 31 2100 – Trenching, Backfilling, and Compaction of Utility Trenches

1.3 REFERENCES

A. ANSI/AWWA C651 – Standard for Disinfecting Water Mains

B. ANSI/AWWA C901 – Polyethylene (PE) Pressure Pipe and Tubing, 3/4" through 3", for Water Service

C. ANSI/AWWA C906 – Polyethylene (PE) Pressure Pipe and Fittings, 4" through 65", for Waterworks

D. AWWA M55 – PE Pipe Design and Installation

1.4 QUALITY ASSURANCE

A. All piping, fittings, and appurtenances installed by the Contractor shall be new and unused and shall be suitable for the intended purposes.

B. Each joint of pipe shall be plainly marked at the site of manufacturer to indicate the class, thickness, and/or strength.

C. The contractor shall provide a complete water system free of leakage and suitable for use as water service to the Owner.

1.5 DELIVERY, STORAGE, HANDLING

A. Pipe and fittings shall be handled in accordance with the PPI Handbook of Polyethylene Pipe. Pipe and fittings shall be loaded and unloaded by strapping and equipment rated for the loads encountered. Chains, wire rope, forklifts, or other methods or equipment that may gouge or damage the pipe or fittings shall not be used. In no case shall the pipe or fittings be dropped.

B. All pipe and fittings shall be shipped with recyclable end caps to ensure no dirt, debris, etc. accumulates. The end caps shall remain in place until the pipe or fittings are to be used.

C. All pipe and fittings are subject to inspection at delivery and other times as deemed necessary by the Owner's Representative. Any pipe and/or fittings damaged during delivery shall be promptly removed from the job site.

D. Pipe and fittings shall be stored off the ground supported by timbers, railings or concrete supports and shall be of sufficient size to avoid contact with the ground or adjacent piping. Supports shall have chocks to prevent movement. Stacking shall be low enough to provide a safe condition, especially in neighborhoods and accessible areas.

E. Pipe and fittings shall be stored to prevent damage to the interior or exterior. The interior of all pipe and fittings shall be kept free of dirt and debris.

PART 2 – PRODUCTS

2.1 APPROVED MANUFACTURERS:

A. J-M Manufacturing Company, Inc.

B. Pipeline Plastics, LLC

C. IPEX USA LLC

D. Centennial Plastics, Inc.

E. Other approved equals as determined by the Owner's Representative

2.2 HDPE PIPE AND FITTINGS FOR 4" THROUGH 65" DIAMETER

A. HDPE pipe 4" through 65" in diameter shall be PE4710 conforming to the latest edition of ANSI/AWWA C906 and ANSI/NSF Standard 61. For potable water applications, PE4710 compound shall conform to ASTM D3350 minimum Cell classification PE445574C-CC3. Refer to PPI TN-44 for CC3 calculations.

1. HDPE pipes shall be extruded by a PPI member with dependent listings in PPI TR-4 and shall meet the requirements of AWWA C906.

2. Dimensions and tolerances for HDPE pipe and fittings shall meet the requirements of AWWA C906.

3. HDPE pipe shall be rated for use at a pressure class of 200 psi (DR 11 pipe dimension ratio). The outside diameter of the pipe shall be based upon the IPS sizing system.

B. Fittings

1. Butt Fusion Fittings – HDPE Fittings shall be made of PE4710 and with a minimum Cell Classification as shown in Section 2.B.1. All HDPE fittings shall meet the requirements of AWWA C906 and shall have a pressure rating equal to the pressure rating of the pipe to which the fitting is joined.

a. Molded fittings shall be manufactured, tested and marked per ASTM D3261.

b. Fabricated fittings shall be manufactured, tested and marked per ASTM F2206, or individual fittings standards.

2. Electrofusion Fittings. Fittings shall be made of HDPE material with a minimum material designation code of PE 4710 and with a minimum Cell Classification as noted in Section 2.B.1. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. Markings shall be according to ASTM F1055.

3. Flanges and Mechanical Joint adapters (MJ adapters). Flanges and MJ adapters shall have a material designation code of PE4710 with a minimum Cell Classification as noted in Section 2.B.1. Flanges shall be made in accordance with ASTM F2880. MJ adapters shall be made to ASTM D3261. Flanges and MJ adapters shall have a pressure rating equal to the pipe to which it is joined unless otherwise specified on the plans. Markings for molded or machined flange adapters or MJ adapters shall be per ASTM D3261. MJ adaptors are the preferred connection method over mechanical fittings. Flanges and MJ adaptors should be double checked for butterfly valve clearance to allow full disc rotation and movement prior to installation in the trench.

2.3 HDPE PIPE AND FITTINGS FOR 3" DIAMETER AND SMALLER

A. HDPE pipe 3" diameter and smaller shall be PE4710 conforming to the latest edition of ANSI/AWWA C901 and ANSI/NSF Standard 61. For potable water applications, PE4710 compound shall conform to

   ASTM D3350 minimum Cell classification PE445574C-CC3. Refer to PPI TN-44 for CC3 calculations.

   1. HDPE pipes shall be extruded by a PPI member with dependent listings in PPI TR-4 and shall meet the requirements of AWWA C901.
   2. Dimensions and tolerances for HDPE pipe and fittings shall meet the requirements of AWWA C901.
   3. HDPE pipe shall be rated for use at a minimum pressure class of 200 psi (DR 11 pipe dimension ratio). The outside diameter of the pipe shall be based upon the IPS sizing system.

B. Fittings

   1. Butt Fusion Fittings – HDPE Fittings shall be made of PE4710 and with a minimum Cell Classification as shown in Section 2.C.1. All HDPE fittings shall meet the requirements of AWWA C901 and shall have a pressure rating equal to the pressure rating of the pipe to which the fitting is joined.
      a. Molded fittings shall be manufactured, tested and marked per ASTM D3261.
      b. Fabricated fittings shall be manufactured, tested and marked per ASTM F2206, or individual fittings standards.
      c. Socket fittings shall meet ASTM D2683.
   2. Electrofusion Fittings. Fittings shall be made of HDPE material with a minimum material designation code of PE 4710 and a minimum Cell Classification as noted in Section 2.C.1. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. Markings shall be according to ASTM F1055.
   3. Flanges and Mechanical Joint adapters (MJ adapters). Flanges and MJ adapters shall have a material designation code of PE4710 with a minimum Cell Classification as noted in Section 2.C.1. Flanges and MJ adapters shall be made in accordance with ASTM D3261 or if machined, must meet the requirements of ASTM F2206. Flanges and MJ adapters shall have a pressure rating equal to the pipe to which it is joined unless otherwise specified on the plans. Markings for molded or machined flange adapters or MJ adapters shall be per ASTM D3261. Fabricated (including machined) flange adapters shall be ASTM F2206.
   4. Service connections shall be electrofusion saddles with a brass or stainless-steel threaded outlet, electrofusion saddles, sidewall fusion branch saddles, or tapping tees.
   5. For electrofusion saddles with threaded outlet the size of the outlet shall be as shown on the plans. Electrofusion saddles shall be made from materials required in Section 2.C.1.
   6. For sidewall fusion saddles, the size of the saddle shall be as indicated on the plans. The saddle can be made in accordance with ASTM D3261 or ASTM F2206.
   7. Tapping tees shall be made to ASTM D3261 or D2683 and MSS SP-60.

2.4 PIPE MARKING AND IDENTIFICATION FOR ALL HDPE PIPE

A. Pipe markings shall include the following items:

   a. Nominal size (such as 3")

b. Outside diameter base (IPS)

c. Pipe dimension ratio (DR 11)

d. Manufacturer's name or trademark

e. Manufacturer's production code, date of manufacture, mark of the certifying agency for potable water (such as NSF)

f. Standard materials designation code (PE 4710)

g. Cell classification (e.g., PE 445574C)

h. PE compound oxidative resistance for potable water (CC3)

i. Pressure class

j. Standard's designation (AWWA C901)

B. Color identification by the use of a continuous BLUE stripe on the crown of the pipe to identify pipe as potable water service. Alternatively, the entire pipe may be BLUE to indicate use as potable water. Fittings are not required to be striped or blue in color.

C. Detector wire shall be installed per the plan details.

PART 3 – EXECUTION

3.1 EXAMINATION

A. The contractor shall examine the site, trench and surrounding conditions to assure proper installation of the pipe and associated fittings.

B. The contractor shall examine pipe and fittings for any exterior or interior gouges or other physical damage prior to its installation.

C. Trenches shall be inspected for proper alignment and grade. Check trench bottom to assure proper clearance from other utilities, pipelines or existing structures.

D. Any bedding required by the drawings or specifications shall be installed prior to pipe placement.

3.2 TRAINING AND INSPECTION

A. Refer to ASTM F3190, ASTM F1290, MAB-01 and MAB-02 for recommended training and inspection for butt-fusion, socket fusion and electrofusion joints. All equipment shall be inspected and personnel training requirements completed and verified prior to commencing construction. Each fusion technician shall be qualified to specifically make the required fusion joint; qualification shall be demonstrated by evidence of training within one year on the equipment and pipe size(s) to be utilized for this project.

3.3 JOINING METHODS

A. The pipe and fittings shall be joined by butt fusion or electrofusion couplings accordance with manufacturer's recommendations. All joints shall be fused.

B. Butt Fusion: The pipe shall be joined by heat fusion of the ends. Prior to fusion the pipe shall be clean, and the ends shall be cut square. Butt-fusion joining is applicable to pipes that have the same nominal outside diameter and wall thickness, within one SDR. Field site butt-fusion system operators shall be

trained in the use of the high-quality butt-fusion equipment that secure and precisely align the pipe ends for the fusion process. Operators shall be trained by the pipe supplier or manufacturer of the fusing machine and be experienced in the operation of the equipment. Fusion quality shall be recorded, the recording of the information must be provided to the Owner. The Owner will review documents within 7 days and identify any fusion records that might indicate the need to replace an existing fused connection. The recorded fusion information must meet the standard requirements of ASTM F3124. All fusions failing to meet these requirements shall be removed and refused. Refer to ASTM F2620, ASTM F3124, ASTM F3183 and ASTM F3190.

C. Saddle fusion: Saddle fusion shall be done in accordance with ASTM F2620 or TR-41 or the fitting manufacturer's recommendations and PPI TR-41. Saddle fusion joints shall be made by qualified fusion technicians. Qualification of the fusion technician shall be demonstrated by evidence of fusion training within the past year on the equipment to be utilized on this project. [Saddle fusion is used to fuse branch saddles, tapping tees, and other HDPE constructs onto the wall of the main pipe] (ASTM F905).

D. Socket Fusion: Molded socket fusion fittings are only to be used for joining of HDPE pipe from ¾" to 2" size. Socket fusion shall be done in accordance with ASTM F2620 or the fitting manufacturer's recommendations. Socket fusion is the process of fusing pipe to pipe, or pipe to fitting by the use of male and female ends that are heated simultaneously and pressed together so the outside wall of the male end is fused to the inside wall of the female end. Qualification of the fusion technician shall be demonstrated by evidence of socket fusion training within the past year on the equipment to be utilized on this project.

E. Electrofusion: Electrofusion joining shall be done in accordance with the manufacturers recommended procedure and ASTM F1055, ASTM F1290, MAB-01 and MAB-02. Qualification of the fusion technician shall be demonstrated by evidence of electrofusion training within the past year on the equipment and pipe sizes to be utilized for this project. Installers shall follow the guidance shown in the previous documents to fabricate EF assemblies. The installer must remove oxidation from the pipe and maintain a clean surface on both pipe and fitting to ensure acceptable joint quality.

F. Mechanical:
   1. Mechanical connection of HDPE to auxiliary equipment such as valves, pumps, and fittings shall use flanges or mechanical joint adapters and other devices in conformance with the PPI Handbook of Polyethylene Pipe, Chapter 9 and AWWA Manual of Practice M55, Chapter 6. Mechanical connections shall be manufactured for HDPE pipe and approved by the connection manufacturer for use with polyethylene pipe. Flanges and MJ adaptors should be double checked for butterfly valve clearance to allow full disc rotation and movement prior to installation in the trench. Uncontrolled tapering or hand-beveling in the field is not allowed.

   2. Mechanical connections on pipe 3" and smaller are available to connect HDPE pipe to a transition to another material. All mechanical and compression fittings shall be recommended by the manufacturer for use with HDPE and with potable water.

   3. Mechanical Joint/Flange. A flange assembly consisting of a metal back-up flange or bolt-ring and a polyethylene flange adapter. MJ assembly consists of a MJ adaptor with gland ring, gasket and bolt kit. Both MJ adapters and flange adapters are fused onto the plain end of the pipe main. Bolting guidance for MJ connections is provided in AWWA C600.

3.4 INSTALLATION

A. Pipe installation shall be according to this section of the specification and the manufacturer's instructions and/or referenced specifications.

B. Every care shall be taken in the handling, cutting, and laying of pipe and fittings to avoid damaging pipe wall. Damaged or defective areas shall be repaired or replaced to the satisfaction of the Owner's Representative.

C. If any gouges, scrapes, or other damage to the pipe results in wall loss of 5% or greater of the pipe wall thickness, such section shall be cut out and not used.

D. Each section of pipe shall be placed in the prepared trench with the full length of the pipe resting upon the pipe bed. No temporary supports under the pipe such as bricks, rocks, etc., shall be permitted.

E. Any pipe found defective shall be replaced. Cracked pipe may be cut as specified previously in this section if authorized by the Owner's Representative.

F. All inside of the pipe and fittings shall be wiped clean and dry and be free from dirt, sand, grit, or any foreign material before the pipe is laid. Foreign material shall be prevented from entering the pipe while it is being placed in the trench. During laying operations, no debris, tools, clothing, or other materials shall be placed in the pipe. Caps shall be placed in the end of pipes and fittings during the installation process.

G. As each length of pipe is placed in the trench, the joint shall be fused, and the pipe brought to correct line and grade as shown on the drawings.

H. At times when pipe laying is not in progress, the open ends of pipe shall be closed by the use of pipe plugs or other methods approved by the Owner's Representative to keep mud, water, and other debris out of the pipe.

I. Pipe cutting for the insertion of valves and fittings shall follow the manufacturer's recommendations. No torch cutting shall be allowed.

J. ANSI/AWWA C906 pressure piping systems joined by heat fusion, electrofusion, flanges, and MJ adaptors are fully self-restrained and do not require external joint restraints or thrust block joint anchors.

K. Water Mains and Accessories. HDPE connections to other pipe materials or valves and fire hydrants shall be made by mechanical joints, flanges or transition fittings. All connections to jointed gasketed pipe materials, valves or fire hydrants must be restrained and supported independently.

   1. Restrained Mechanical Joints: Restrained mechanical joints shall be made using mechanical joint adapters. Refer to the manufacturer's instructions on the need for stiffeners when installing a mechanical joint.

   2. Flange: Flange connections shall be as described in Section 4.3.B.

L. All appurtenances (tees, elbows, services, valves, air relief valves, fire hydrants, etc.), must be independently supported and shall not rely on the pipeline and its connections for this support. Excessive stresses may be encountered when appurtenances are inadequately supported.

M. Cold bending of the pipe in the trench shall be limited a maximum bending radius of twenty-five (25) times the HDPE pipe outside diameter.

N. Trenches shall be backfilled according to Section 31 2100.

3.5 TESTING

All testing shall be as indicated in Section 33 2660, Water System.

END OF SECTION 332601

SECTION 33 26 05

PRECAST CONCRETE MANHOLES

PART 1 – GENERAL

1.1 SUMMARY:

A. This section of specifications covers the material and installation requirements for precast concrete manhole sections with tongue-and-groove joints, masonry transition to manhole frame, covers, anchorage and accessories.

1.2 RELATED SECTIONS:

A. Section 31 2100 – Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2433 – Reinforced Concrete Pipe

1.3 REFERENCES

A. ASTM A48 – Standard Specifications for Gray Iron Castings.

B. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

C. ASTM C487 – Standard Specification for Precast Reinforced Concrete Manhole Sections.

D. ASTM C923 – Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes.

E. International Masonry Industry All-Weather Council (IMIAC): Recommended Practices and Guide Specification for Cold Weather Masonry Construction.

1.4 QUALITY ASSURANCE

A. All precast manhole sections and appurtenances installed by the Contractor shall be new, unused and shall be delivered directly to the job site from the manufacturer. The date of manufacturer and the name or trademark of the manufacturer shall be clearly marked on the outside of the barrel.

B. Manholes shall be handled, transported, delivered, and stored by methods that will not damage the pipe. Any damaged sections will be rejected and shall be replaced by the Contractor at no additional cost to the project.

C. Masonry construction shall not be performed when ambient temperatures are 40 degrees F and falling unless provisions for heating and protecting the work are approved. Protect new masonry from freezing for 48 hours after completion of the masonry work.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Precast Manhole Base and Sections:

i. Precast concrete manholes shall be of reinforced concrete manhole sections conforming to the requirements of ASTM C478. The concrete when tested in compression shall not be less than 4,000 psi and absorption shall not exceed 9%.

ii. Precast concrete manhole base and sections shall be a minimum of 48 inches inside diameter. Precast concrete manhole base sections shall have a minimum wall thickness of 5 inches and minimum bottom thickness of 6 inches. Minimum wall thickness of the manhole riser sections shall

be 5 inches for 48 I.D. sections, 6 inches for 60" I.D. sections, and 7 inches for 72" I.D. sections.

iii. Manhole base, riser, transition and cone sections shall have offset tongue and groove joints and shall be made watertight with pre-lubricated rubber gaskets conforming to ASTM C443 and butyl sealant waterstops. Pre-lubricated gaskets shall be Tylox Superseal as manufactured by Hamilton-Kent; butyl sealant waterstop shall be ConSeal CS-231, in widths as recommended by the manufacturer.

iv. Manholes shall be assembled with the fewest number of sections to makeup the required height, thereby reducing the number of joints. The use of more than one riser section of 16 inches or less shall be prohibited. The Engineer may require that any manhole not composed of the minimum number of sections be replaced.

v. Precast eccentric cone shall be provided as the top section of manhole. Eccentric cone shall have the same reinforcing as manhole base and sections. Cone sections shall be made with a minimum 5-inch wall thickness at the bottom and 8" wall thickness at the top. Where watertight manhole frame and covers are indicated on the drawings, cone sections shall be supplied with four (4) stainless steel anchor bolts.

vi. Two lift holes shall be cast into each cone or riser section for purposes of handling and placement.

vii. Openings for inlet and discharge sewer pipes shall be provided in the manhole base section and in the riser section for drop manholes. Openings shall be at positions and elevations as indicated on the plans and may be cast into the manhole wall or mechanically cored at the manufacturing facility. Openings shall be sized to accommodate the flexible manhole sleeve.

B. Precast Concrete Adjusting Rings:
   i. Provide precast concrete adjusting rings, as required, between top of eccentric cone and finished grade.

   ii. Precast concrete adjusting rings shall be of the same materials of construction as manhole bases and sections, grooved top and bottom.

   iii. Adjusting rings shall be 3 or 4 inches high by 5 inches thick. Maximum combined height of adjustment rings shall be limited to 12 inches.

C. Flexible Manhole Sleeves:
   i. Flexible manhole sleeves suitable for use in precast or cored openings utilizing pre-molded shapes positioned with expansion rings shall comply with the requirements of ASTM C923 and shall be manufactured by KOR-N-SEAL or approved equal. Flexible connectors shall be installed as recommended by the manufacturer.

D. Manhole Steps:
   i. Manhole steps shall be Copolymer Polypropylene Plastic Coating over 1/2-inch minimum Grade 60 steel reinforcing, 12 inches wide, with slip resistant surface.

   ii. Manhole steps shall conform to ASTM C78 as manufactured by M.A. Industries, Model PSI-PF, or equal. Steps shall be centered under the manhole cover opening and be vertically aligned on 16-inch centers.

E. Manhole Frames and Covers:
   i. Manhole frames and covers shall be close-grained, cast iron, smooth, clean, free of blisters, blowholes and other defects and conform to ASTM A48, Class 30B. Plane or grind bearing surfaces

to ensure a flat, fine surface. Castings judged to be defective by the Owner's representative will be rejected and shall be replaced by the Contractor.

ii. Covers and frames shall be "Heavy-Duty" type, rated for a minimum of H-20 loading, and made in the United States.

iii. Manhole covers shall be cast with two non-penetrating type pick holes. Covers shall not have vent holes.

iv. Manhole frames and covers shall be of either Standard Type (non-bolted) or watertight type (bolt-down), as indicated on the drawings. If not indicated, manhole covers shall be standard type. In locations where the manhole rim elevation is below the 100-year flood elevation, manhole frame and covers shall be watertight.

v. Manhole frames and covers shall conform to the manufacturer dimensions and as shown on the drawings.

vi. When watertight frames are required, manhole joints shall be supplied with 3" x 16" x 1/2" bitumastic-coated steel strap anchors and bolts as shown on the drawings.

F. Non-Shrink Grout

i. Non-shrink grout shall be used to seal openings in the manhole base and riser sections such as lift holes and around flexible sleeve connections as shown on the standard details. Non-shrink grout shall be Thoro WaterPlug or approved equal.

ii. Surface preparation, mixing and application shall strictly adhere to manufacturer's recommendations.

PART 3 – EXECUTION

3.1 EXCAVATION AND BACKFILL:

A. Perform excavation to lines and grades established by the drawings. Construct excavation a minimum of two (2) feet in diameter larger than the outside dimensions of the manhole base and sections

B. If material in bottom of excavation is unsuitable for supporting manhole, excavate unsuitable material to a depth specified by the Engineer and backfill resulting void with Alabama Department of Transportation No. 57 crushed stone.

C. Backfill around manholes constructed in paved areas or areas to be paved with Alabama Department of Transportation 825, Type "B". Compact backfill in 8-inch loose lifts to a minimum density of 95% Standard Proctor Density with vibratory compaction equipment.

D. Backfill around manholes in unimproved areas and lawns with native materials, compacted in 8-inch loose lifts to minimum density of 95% Standard Proctor Density.

3.2 GRANULAR BASE

A. Remove standing water from excavation. Place 12 inches minimum of Alabama Department of Transportation No. 57 crushed stone and compact with vibratory compaction equipment.

B. Excavations deeper than 12 inches below required grade of manhole base, not approved by the Engineer, shall be filled with Alabama Department of Transportation No. 57 crushed stone and compacted by vibratory compaction equipment at no additional cost to the project.

3.3 PLACING MANHOLE BASE AND SECTIONS

A. Manholes shall be constructed to the sizes, shapes, dimensions, and at the locations shown on the plans.

B. Precast concrete manhole bases shall be set plumb and true to the lines and grades specified by the plans. Manholes out of plumb in excess of 1/4 inch in eight (8) feet shall be reset.

C. Clean ends of manhole sections of foreign materials and inspect ends for damage.

D. Place pre-lubricated gasket into recess. Place butyl sealant waterstop. Follow gasket and waterstop manufacturer's installation instructions. Set manhole section. In addition to the joint butyl sealant gaskets, each manhole joint shall be sealed on the exterior with a polyolefin backed exterior joint wrap at each manhole joint section, including the top section. The exterior joint wrap shall meet the requirements of ASTM C877 Membrane Waterproofing and Exterior Joint Wrap for Precast Concrete Joints) and be a minimum of 9" wide with a minimum thickness of 0.065", installed as per the manufacturers recommendations and instructions. Exterior joint wrap shall be ConWrap CS-212 as manufactured by ConSeal Concrete Sealants, inc. or approved equal. The exterior wrap shall also be applied at all pipe entrances / exits from the manhole, in addition to the typical grout seal of such connections. Wrap at each pipe / manhole connection shall be layered in sections with a minimum length of 18" centered on the manhole wall interface with a minimum of 3" overlap of the sealant material.

E. When new openings are required in existing manholes, openings shall be core drilled.

F. Install flexible manhole sleeves on pipes at the precast or core drilled openings according to manufacturer's recommendations. Grout around flexible sleeves as shown on the drawings.

G. Seal lifting holes and flexible manhole sleeves in manhole on the interior and exterior with non-shrink grout to divert infiltration.

3.4 MANHOLE INVERT

A. Manhole inverts shall be constructed of cement mortar and shall have the same cross-section as the invert of the sewers which they connect. The manhole invert shall be carefully formed to the required size and grade by gradual and even changes in sections. Changes in direction of flow through the sewer shall be made to a true curve with as large a radius as the size of the manhole will permit.

B. For pipe diameters less than 48 inches, a bench shall be constructed on each side of the flow channel. The bench shall slope one (1) inch per foot. Bench shall be made of non-shrink grout.

C. Where the difference in the invert elevation of two or more sewers 18 inches in diameter or smaller intersecting in one manhole is 9 inches or more, a drop manhole shall be constructed in the manner shown on the Drawings. They shall be similar in construction to the standard manhole except that a drop connection of pipe and fittings of the proper size and material shall be constructed outside the manhole and supported by 3,000 psi concrete. The manhole and drop connection shall be placed on a 12-inch reinforced concrete foundation base. The drop connection piping assembly shall be bolted to the barrel of the manhole riser. Drop connection piping shall be ductile iron.

3.5 MANHOLE FRAMES AND COVERS

A. Install manhole frames and covers with top surface adjoining surrounding grade in improved areas. Where manholes are constructed in paved areas, the top surface of the frame and cover shall be tilted so as to conform to the exact slope, crown and grade of the pavement adjacent thereto. Set manhole frames at the required elevation in a full bed of grout to provide proper bonding to cone section and/or concrete adjusting rings.

B. Where a manhole frame elevation requires adjustment, precast concrete adjusting rings shall be used. A minimum 1/4-inch bed of non-shrink grout shall be placed between the manhole cone section and the adjusting ring. Same grout thickness shall be provided in between adjusting rings when multiple rings are necessary. Butyl sealant waterstop shall be placed beneath the frame and in between each concrete adjusting ring as shown on the drawings. Butyl sealant shall be ConSeal CS-231.

C. Manhole frame shall be positioned concentrically above the precast cone section or adjusting rings and set in a full bed of non-shrink grout. A thick ring of non-shrink grout extending to the outer edge of the precast cone section or adjusting ring shall be placed all around and on top of the manhole frame. The non-shrink grout shall be smoothly finished and have a slight slope to shed water away from the frame and cover.

D. Check manhole cover for fit in frame. If a manhole cover is either excessively loose or tight, rocks, wobbles, or moves in the frame, the frame and cover shall be removed and replaced by the Contractor.

3.6 MANHOLE HEIGHT ADJUSTMENT

A. Adjust height of existing manholes at locations shown on the drawings. Height adjustment may include lowering or raising the existing manhole.

B. Height of manhole shall be adjusted such that the rim and cover are flush with the proposed pavement, concrete, or adjacent grade.

3.7 PROTECTIVE COATINGS:

A. Where shown on the drawings or directed by the Engineer, manholes shall be protected from corrosion by the use of factory applied ceramic epoxy linings.

B. Epoxy coating shall be an amide cured ceramic epoxy, Permite PCS-9043 Type II or approved equal. The epoxy shall be applied to a 40 mils dry film thickness on the inside of the structure per the manufacturer's recommendations.

END OF SECTION 332605

SECTION 33 26 60
WATER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This section of specifications covers the testing, disinfection, and general installation requirements for potable water system and / or distribution lines.

1.2 RELATED SECTIONS AND DOCUMENTS

A. Drawings and general provisions of the Contract Documents including General, Supplemental, and Special Conditions, and Division 01 Specification Sections, apply to this Section.

B. Technical Specifications:

i. Section 31 2100, Trenching, Backfilling, and Compaction of Utility Trenches

ii. Section 33 2600, Ductile Iron Pipe and Fittings

iii. Section 33 2601, High-Density Polyethylene Pipe and Fittings

iv. Section 33 2660, Water System

v. Section 33 2662, Gate Valves

vi. Section 33 2668, Fire Hydrants

vii. Section 33 2664, Valve Boxes and Vaults

1.3 REFERENCES

A. AWWA C300 AWWA Standard for Hypochlorite

B. AWWA C301 AWWA Standard for Liquid Chlorine

C. AWWA C600 AWWA Standard for the Installation of Ductile Iron Water Mains and their Appurtenances.

D. AWWA C651 AWWA Standard for Disinfecting Water Mains

E. AWWA C900 AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4-inch through 12-inch, for Water.

1.4 SYSTEM REQUIREMENTS

A. The Contractor shall furnish a complete and operable water system, installed according to the standards and accepted practices for waterline construction. These specifications and references specifically called for in these specifications shall be considered minimum, other incidental items may be necessary to construct a complete and operable water system.

B. The water system shall be free of leakage as defined in Section 02660, Part 3.B.2.f and ready for use by the Owner upon final acceptance.

1.5 REGULATORY REQUIREMENTS

A. The Contractor shall familiarize himself with the regulatory requirements of the following governing agencies. Any deviations specified in these specifications from these agency requirements shall be

promptly brought to the attention of the Engineer.

i. Alabama Department of Environmental Management

ii. The Owner

iii. Local Water Works Department

iv. American Water Works Association

1.6 SITE CONDITIONS

A. The Contractor shall familiarize himself with existing conditions & special site requirements of the job.

B. Any street cuts or crossings shall be coordinated with the Owner and/or Owner's Representative. Any and all traffic control measures specified shall be incorporated by the Contractor.

C. Street cuts or crossings along or across State of Alabama Department of Transportation Right-of-Way shall follow the guidelines and requirements of the Alabama Manual on Uniform Traffic Control Devices.

D. The Contractor shall contact the City of Tuscaloosa Water Works Department concerning the use of water to be used in the flushing, pressure testing, and disinfection if project is associated with the City of Tuscaloosa Water System.

E. The Contractor shall take appropriate measures to control the disposal of water used in the testing, flushing and disinfection of water lines. The Contractor shall adequately protect streets and adjacent property from the discharge of this water. Any damages shall be borne by the Contractor. Water used for disinfection may contain high concentrations of chlorine. Any environmental damage to lakes or streams shall be the sole responsibility of the Contractor.

F. The Contractor shall coordinate with the Owner’s Representative and water works officials on the timing of all tests, flushing, and disinfection of all water lines.

G. The Contractor shall coordinate with the Owner’s Representative and water works officials on all tie-ins to existing system lines and valves.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. All manufacturers of equipment used in the water line and/or system shall be experienced in the manufacture of such equipment for the water industry.

B. Equipment of like nature shall be of the same manufacturer as to maintain standardization of operation, maintenance, spare parts and manufacturer's service.

2.2 EQUIPMENT AND MATERIALS

A. All equipment used in the water system shall be new and unused, first quality and from established manufacturers.

B. Equipment shall meet the requirements of the related sections of these specifications and associated governing agency.

2.3 TESTING EQUIPMENT

A. The Contractor shall have on hand proper testing apparatus and associated accessories prior to beginning any tests. All fittings, piping, pressure gauges and pumps shall be in proper working order.

PART 3 – EXECUTION

3.1 THRUST BLOCKING

A. All pressure pipe 2-inches in diameter and over shall be provided with thrust restraints. Thrust restraints shall consist of concrete thrust blocks and/or mechanical restraining rods and attachments shall be furnished at all hydrants, valves, fittings, plugs, and pipe bends.

B. The bearing area for concrete thrust blocking shall conform to 24-hour test. Special blocking detailed in the Construction Plans shall supersede these requirements.

C. Concrete used in thrust blocking shall have a minimum compressive strength of 2000 psi in 28-days.

D. The concrete blocking shall be placed in such a way to contain the thrust force and still maintain accessibility of the pipe and fittings for repair. Nuts, bolts, glands, etc. shall be free of concrete. No separate payment shall be made for concrete blocking or thrust restraint.

E. Fire hydrants shall be restrained as detailed in the Construction Plans.

F. All restraining rods, clamps, and accessories shall be coated with a bitumastic coating before and after installation. The surface shall be cleaned thoroughly and the bitumastic coating applied as per manufacturer's recommendations.

3.2 TESTING

A. Flushing:

i. Prior to beginning the pressure test, the water line shall be flushed to remove any dirt and debris trapped in the line. All valves shall be partially opened and closed during the flushing process.

ii. All mains shall be flushed with a velocity of at least 2.5 feet per second as specified by the Alabama Department of Environmental Management prior to any disinfecting sampling.

B. Hydrostatic Pressure Test:

i. PVC and Ductile Iron

a. The Contractor shall coordinate with the Owner and slowly fill the section of line to be tested with water. The line shall then be pressurized to 1.5 times the working pressure of the line, but in no case less than 150 psi. The working pressure shall be as defined by the Owner.

b. Trapped air shall be expelled at all valves and hydrants. High points in the line without access to a valve or hydrant shall be tapped and a corporation stop installed. Upon completion of the test, the corporation stop shall be left in place. A copper line shall be installed from the corporation stop to a curb stop and a meter box installed.

c. Upon complete removal of all air entrapped in the line, the line shall be again filled with water and pressurized and testing begun. Duration of the test shall be two hours for uncovered pipe and six hours for covered pipe. The test pressure shall not vary by + or - 5 psi during the duration of the test.

d. A recording pressure gauge shall be installed and pressure fluctuations recorded for the duration of the test. Test charts and records shall be provided to the Owner's Representative at the end of each test. Charts shall be labeled with the date, time, length / diameter of main(s) being tested, leakage / water added, etc.

e. All visible leaks encountered during testing shall be immediately repaired.

f. Leakage shall not be greater than determined by the following formula:

$$L = \frac{SDP^{1/2}}{148{,}000}$$

L = Allowable leakage in gallons per hour
S = Length of tested pipe (ft.)
D = Diameter of pipe (in.)
P = Average test pressure during the duration of the test (psi)

g. Leakage in excess of that determined by the above formula shall be repaired at the expense of the Contractor. The leakage test shall then be repeated until the project complies with the allowable leakage.

h. Per City of Tuscaloosa requirements, a meter shall be used during the duration of the test to determine if the volume of water required to maintain the test pressure exceeds the total allowable leakage.

i. Mains sixteen (16) inches and greater in diameter shall be pigged prior to flushing, testing, and disinfecting. Fittings for pigging shall be provided and remain accessible for future pigging by the Owner.

ii. High-Density Polyethene

a. Hydrostatic pressure testing for HDPE shall consist of two phases, the initial phase being a pipe expansion phase and the second phase consisting of the actual testing.

b. As part of the initial expansion phase, the Contractor shall coordinate with the Owner and slowly fill the section of line to be tested with water. The line shall then be pressurized to 1.5 times the working pressure of the line, but in no case less than 150 psi. The working pressure shall be as defined by the Owner.

c. Trapped air shall be expelled at all valves, end of line, meters, etc. High points in the line without access to a valve or other outlet shall be tapped and a corporation stop installed. Upon completion of the test, the corporation stop shall be left in place. A copper line shall be installed from the corporation stop to a curb stop and a meter box installed.

d. During the initial line expansion phase, sufficient make-up water shall be added to the system at hourly intervals for three (3) hours to maintain the test pressure. This initial expansion phase shall last for four (4) hours.

e. Assuming there is no obvious leakage during the initial expansion phase, immediately following the four (4) hour expansion period the line shall be topped off with water and repressurized to the designated and constant test pressure as stated in paragraph 3.B.2.b.ii. The test phase shall be for three (3) hours at which time any water deficiency must be replaced and measured. The amount of make-up water required to return to the designated test pressure shall be compared to the maximum allowance in the table below to determine if the line is acceptable. All make-up water shall be measured with a meter to actually determine the amount of water required.

ALLOWANCE FOR EXPANSION UNDER TEST PRESSURE			
NOMINAL PIPE SIZE	U.S. GALLONS PER 100 FT OF PIPE		
	1 HOUR	2 HOURS	3 HOURS
Up to 1-1/2"	0.06	0.10	0.16
2"	0.08	0.12	0.15
3"	0.10	0.15	0.25
4"	0.13	0.25	0.40
5"	0.21	0.41	0.63
6"	0.30	0.60	0.90
8"	0.50	1.00	1.50
10"	0.75	1.30	2.10
12"	1.10	2.30	3.40

f. An acceptable alternative leakage test shall consist of maintaining the constant test pressure as stated in paragraph 3.B.2.b.ii over a period of four (4) hours. After the four-hour test duration, lower the line pressure by 10 psi and allow the line to stabilize for a minimum of fifteen (15) minutes. If the pressure remains with five (5) percent of the test pressure as stated in paragraph 3.B.2.b.ii for one (1) hour the line shall be acceptable.

g. Under no circumstances shall the total line pressurization exceed eight (8) hours from the initial expansion phase through the test phase. If the test is not completed within this time frame (due to leakage, equipment failure, etc.) then the line segment shall be relaxed for a minimum of eight (8) hours, at which time the entire process shall be repeated.

h. A recording pressure gauge shall be installed and pressure fluctuations recorded for the duration of the test. Test charts and records shall be provided to the Owner's Representative at the end of each test. Charts shall be labeled with the date, time, length / diameter of main(s) being tested, leakage / water added, etc.

i. All visible leaks encountered during testing shall be immediately repaired.

j. Leakage in excess of that determined by the above method shall be repaired at the expense of the Contractor. The leakage test shall then be repeated until the project complies with the allowable leakage.

k. A meter shall be used during the duration of the test to determine if the volume of water required to maintain the test pressure exceeds the total allowable leakage.

C. Disinfection:

i. After a successful pressure test has been achieved, the waterline shall be chlorinated for the purpose of disinfection.

ii. The Contractor shall use the hypochlorite continuous feed method for chlorine application as

specified in AWWA Standard C651.

iii. Chlorine solution shall be introduced to achieve a concentration of at least 50 mg/l in all parts of the line.

iv. The chlorine solution shall be allowed to remain in the pipe for a period of not less than 24-hours at which time the chlorine concentration shall be not less than 25 mg/l.

v. All pipe and appurtenances shall be flushed with clean water until the chlorine residual is reduced to 1 mg/l or less until compatible with the existing system. The Contractor shall not flush any lines unless the local Water Department is present.

vi. Bacteriological samples shall be collected in sterile jars by the Contractor.

vii. The Owner shall perform the water analysis. All costs associated with the disinfection shall be borne by the Contractor.

viii. The water line and appurtenances shall not be placed in service until an acceptable laboratory analysis has been completed.

ix. If the initial disinfection fails to produce satisfactory samples, disinfection as required above shall be repeated by the Contractor at his expense until satisfactory samples have been obtained.

3.3 EXISTING UTILITY CROSSINGS

A. Water mains paralleling existing sanitary sewers shall be positioned a minimum of 5-feet horizontally from the sewer.

B. If insufficient space is available to maintain the 5-foot separation, the bottom of the waterline shall be placed a minimum of 18-inches above the top of the sewer.

3.4 PROTECTION

A. The Contractor shall maintain and protect the completed water line until final acceptance by the owner. Any damages to the line shall be repaired by the Contractor prior to acceptance.

END OF SECTION 332660

SECTION 33 26 62

GATE VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the material, installation, and performance criteria for resilient seated gate valves, including tapping sleeves and valves, to be used in water service.

1.2 RELATED SECTIONS

A. Section 31 2100 - Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2660 - Water System

C. Section 33 2664 - Valve Boxes and Vaults

1.3 UNIT PRICES

A. Gate Valves shall be paid for per each if a bid item is denoted in the Bid Schedule. If a specific bid item is not denoted in the Bid Schedule or project is bid as a lump sum, payment for resilient seated gate valves shall be incidental to the overall cost of the Project. Payment, in either case, shall be based on a complete, installed, and operable valve with valve box and concrete support considered incidental to the installation of the valve. This payment shall include compensation for all appurtenances, materials, labor, etc. necessary to complete the work.

B. Tapping Sleeve and Valve shall be paid for per each, if a bid item is denoted in the Bid Schedule. If a specific bid item is not denoted in the Bid Schedule, or project is bid as a lump sum, payment for resilient seated gate valves shall be incidental to the overall cost of the Project. Payment, in either case, shall be based on a complete, installed, and operable tapping sleeve and valve, valve box, testing, and concrete support considered incidental to the installation of the sleeve and valve. This payment shall include compensation for all appurtenances, materials, labor, etc. necessary to complete the work.

1.4 REFERENCES

A. AWWA C509 American Water Works Standards for Resilient Seated Gate Valves for Water Supply Service.

B. AWWA C515 American Water Works Standards for Reduced-Wall Resilient Seated Gate Valves for Water Supply Service.

C. AWWA C550 American Water Works Standards for Protective Epoxy Interior Coatings for Valves and Hydrants.

D. AWWA C600 American Water Works Association Standard for Installation of Ductile-Iron Water Main and their appurtenances.

1.5 SUBMITTALS

A. The contractor shall furnish detail assembly drawings, specifications, catalog data and dimensions, and 5 sets of operating instructions for all valves.

1.6 QUALITY ASSURANCE

A. The contractor shall supply to the Owner's Representative an affidavit from the manufacturer that all gate valves 2- inches and larger conform to AWWA C509 or AWWA C515 and that all tests specified therein have been performed and all test requirements have been met.

B. The contractor shall supply to the Owner's Representative an affidavit of compliance from the manufacturer that all gate valves smaller than 2-inches conform to Federal Specification WW-V-54 and have a pressure rating of 200 psi minimum.

1.7 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:

1. Markings shall be cast on the bonnet or body of each valve conforming to AWWA C509 or AWWA C515.

2. Valves shall be packaged for shipment to avoid damage during shipping and handling. All gate valves shall be completely drained and closed prior to shipment.

B. Acceptance at Site:

1. Gate valves shall be thoroughly checked at the site prior to unloading. Any valves found defective or damaged during shipment will be rejected.

2. The contractor shall provide adequate lifting equipment to unload large valves. In no case should valves be dropped.

3. Chains, hoists or other lifting devices should not be fastened around bypasses, yokes, gearing, motors, stems or handwheels. Valves shall not be lifted by the stem.

C. Storage and Protection:

1. Valves should be stored in a closed position and protected from rain, dirt and debris by covering or storing indoors. In freezing weather, the contractor shall take steps to assure valves do not freeze.

2. Rubber gaskets for joints shall be stored in a cool, dry place out of direct sunlight. Avoid contact between petroleum-based substances and rubber gaskets.

3. Gate valves shall be stored such that the resilient coating on the interior of each valve is not exposed to direct sunlight for extended periods of time. In addition, each valve shall be stored to avoid exposing the epoxy interior coating to nicks and abrasions.

1.8 SCHEDULING

A. The contractor shall schedule deliveries of gate valves to assure the proper materials are on hand prior to the installation of the work.

PART 2 – PRODUCTS

2.1 APPROVED MANUFACTURERS

A. American Cast Iron Pipe Company

B. U.S. Pipe

C. Clow

D. Mueller

E. M & H Valve Company

2.2 EQUIPMENT

A. Gate valves 4-inches through 12-inches:

1. Gate valves shall conform to AWWA C509 or AWWA C515
2. Gate valves shall be iron-bodied, resilient wedge unless otherwise noted with an asphalt varnish exterior coating or approved equal.
3. Operating nuts shall be 2-inch square with 'O' ring seals, operating in a counterclockwise motion to open the valve.
4. Gate valves shall be mechanical joint if buried and flange joint if located inside or attached to structures. Retainer glands shall be used with mechanical joints unless otherwise specified.
5. Valves shall be non-rising stem type, unless specifically denoted otherwise, capable of removal without disassembly of the valve and interchangeable with like size valve stems.
6. The interior coating shall be fusion bonded epoxy conforming to AWWA C550.
7. The iron valve body shall be hydrostatically tested to 500 psig and the completed valve shall be bubble tight to 250 psig.

B. Gate Valves 2-inch and smaller:

1. Gate valves shall be bronze, Stockham B103, or equal.
2. Gate valves shall conform to Federal Specification WW-V-54, Class 150.
3. Gate valves to have non-rising stem with inside screw type solid wedge disc.
4. Gate valve body, bonnet and disc to be bronze, meeting ASTM Specifications B-62.
5. Packing nut and stuffing box to be bronze, meeting ASTM Specifications B-584.
6. Packing gland to be brass.
7. Handwheel to be malleable iron, meeting ASTM Specifications A-197.
8. Handwheel nut to be steel.
9. Full port opening. Disc to recess completely into bonnet.
10. Packing to be non-asbestos Kevlar with Teflon.

C. Gate Valves 14-inch through 48-inch:

1. In general, resilient seated gate valves, 14-inch through 48-inch shall conform to the requirements for resilient seated gate valves 4-inches through 12-inches except for the requirements denoted below:
    a. Unless denoted otherwise the operating stem shall be horizontal.
    b. The operating nut shall operate a fully enclosed gear drive to operate the valve stem and open and close the valve.

c. Gears shall be smooth running, accurately cut and made from ASTM A26 Grade U- 60-30 steel.

d. Gear ratios shall conform to Table 7 of AWWA C500.

e. Fully enclosed gear cases designed for underground use shall be provided.

f. The iron body shall be hydrostatically tested to 400 psig and the completed valve assembly shall be bubble tight at 200 psig.

2. Bypasses shall be provided for all valves 24-inches and larger.

a. Bypass sizing shall conform to Table 8 of AWWA C500.

b. Valves used for bypasses shall be non-rising stem gate valves of the same size as specified in Table 8 of AWWA C500.

c. Valves used for bypass shall conform to these specifications.

d. Piping used in bypasses shall be ductile-iron, mechanical joint conforming to Section 02600, Ductile Iron Pipe and Fittings.

D. Tapping Valve and Sleeve:

1. All tapping Valves shall comply with AWWA Specifications C-509 for resilient seat valves and the following design specifications:

a. All tapping valves are to be non-rising stem type, unless specifically denoted otherwise, capable of removal without disassembly of the valve and interchangeable with like size valve stems.

b. Operating nuts shall be 2-inch square with 'O' ring seals, operating in a counterclockwise motion to open the valve.

c. Tapping valves 12" smaller have a working pressure of 200 psig and tested at 400 psig Tapping valves 14" and larger shall have a working pressure of 150 psig and test pressure of 300 psig.

d. All tapping valves must be furnished with "O" Ring seals.

e. Tapping valves shall have an outlet end connection of the mechanical joint type. Inlet ends shall have an inlet flange for the attaching to a sleeve or cross. A machine projection on this flange shall be made with a machined recess in the tapping sleeve outlet flange to assure correct alignment.

f. Seat opening of tapping valves shall be larger than the nominal size to permit full diameter cuts to be made.

g. All valves to have tapping sleeve ends complete with bolts, glands and 1/8" thick rubber gaskets.

2. Tapping sleeves shall be suitable for use on pipe with AWWA specifications C102-53, C105- 53, C108-53 and the following design specifications:

a. Tapping sleeves shall be full body mechanical joint type. No fabricated type tapping sleeves shall be used unless specifically indicated on the plans. The mechanical joint ends shall be sealed by neoprene gaskets, compressed tightly around mains by means of a second flange or gland bolted to the end flange of the sleeve. Gasket and its seat inside the end flange or the sleeve shall be tapered or wedge shaped. The gasket shall be totally confined to prevent cold flow when gland is tightened.

b. Tapping sleeves shall have a minimum working pressure of 200 psig.

c. The side outlet or branch connection outlet shall be machined and with a machined recess match the machined projection of the tapping valve flange to assure correct alignment.

d. The longitudinal or side gaskets shall be of neoprene and shall be confined in a cored grove.

2.3 FABRICATION

A. Valves shall be fabricated and assembled to be well fitted and to operate smoothly.

B. Parts shall be designed and manufactured to be interchangeable between manufacturers of the same type and size.

C. Castings shall be sound and free from defects.

2.4 SOURCE QUALITY CONTROL

A. Each gate valve shall be subjected to an operation test and hydrostatic test at the place of manufacture.

B. The contractor shall supply to the Engineer an affidavit of compliance as specified in 1.06.A and B of these specifications.

C. Operation and hydrostatic testing shall conform to applicable section of AWWA C509 or AWWA C515.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Prior to the installation of the gate valve, the valve should be examined and inspected for compliance with these specifications and proper operation.

B. Valves that fail to comply with these specifications or operate properly shall be removed from the jobsite without compensation.

C. All gate valves shall be operated through one complete cycle by the Contractor in the presence of the Owner's representative to verify proper operation.

3.2 PREPARATION

A. Prior to installation of the valve, the contractor shall prepare the area for valve installation by supporting the associated piping to align the valve.

B. The contractor shall determine that proper materials are on hand for a complete valve installation.

C. The contractor shall review the manufacturer's installation instructions to ascertain that no unusual installation procedures are required. Should the contractor find any unusual procedures, he shall promptly report them to the Engineer.

3.3 INSTALLATION

A. All gate valves installed underground shall be installed in a closed position.

B. Gate valves shall be installed on a firm footing and temporarily supported until a permanent support can be poured. Pipe ends should be supported to minimize bending to the valve end connections.

C. A valve box or vault shall be installed around all gate valves. The contractor shall refer to the drawings for any special vaults to be constructed. If no special vault is specified a valve box shall be installed.

D. Valve boxes and vaults shall be installed to avoid traffic and other surface loading being transmitted to the valve.

E. Valve boxes shall be centered over the operating nut with the top flush with the surrounding finished elevations.

F. Large valves installed with bypasses shall have a second valve box installed, centered over the smaller bypass valve operating nut.

G. Valves installed in deep trenches with the operating nut located six feet below the finished surface shall have stem risers provided for operation with a six-foot key.

H. Gate valves installed above ground shall be supported to avoid excessive stress and bending to the valve end connections.

3.4 FIELD QUALITY CONTROL:

A. After installation, but prior to pressure testing, all bolts shall be checked with a torque wrench for proper torque.

B. Gate valves shall be left uncovered during hydrostatic testing to check for leaks unless test pressures are great enough to cause unstable conditions at the valve.

C. Gate valves shall not be tested at pressures greater than twice the rated working pressure of the valve.

3.5 RECORDS:

A. The contractor shall sufficiently mark all gate valve locations and record the size, make, date of installation, and number of turns necessary to open. The contractor shall furnish the Engineer with 3 copies of such records.

3.6 PROTECTION:

A. The contractor shall protect all gate valves from damage until final acceptance of the work.

END OF SECTION 332662

SECTION 33 26 64

VALVE BOXES AND VAULTS

PART 1 – GENERAL

1.1 SUMMARY

A. This section of specifications covers the materials and installation for valve boxes and vaults.

1.2 RELATED SECTIONS AND DOCUMENTS

A. Drawings and general provisions of the Contract Documents including General, Supplemental, and Special Conditions, and Division 01 Specification Sections, apply to this Section.

B. Technical Specifications:

i. Section 31 2100, Trenching, Backfilling, and Compaction of Utility Trenches

ii. Section 33 2600, Ductile Iron Pipe and Fittings

iii. Section 33 2662, Gate Valves

1.3 SECTION SUBMITTALS

A. Valve Boxes. The Contractor shall submit product data including catalog cuts, manufacturer's data and other incidental information on valve boxes for normal sized water, sewer, gas valves.

B. Valve and Meter Vaults. The Contractor shall submit product data including catalog cuts, shop drawings, manufacturer's data, and other incidental information for approval prior to installation of all vaults, lids, and covers for meters, valves, etc. of water services items such as large meters, pressure reducing valves, backflow preventors, etc.

1.4 QUALITY ASSURANCE

A. Valve Boxes. Valve boxes shall be cast by a foundry with at least five years' experience in the casting of valve boxes and covers.

B. Vaults:

i. Vaults shall be built according to detail drawings specified in the drawings. The Contractor shall construct the vaults in a neat and workmanlike manner.

ii. Vault covers shall be fabricated according to the detail drawings and shop drawings approved by the Architect. Vault covers shall be fabricated in a neat and workmanlike manner.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Valve Boxes
   i. Opelika Foundry, #4905
   ii. Tyler Foundry, #6850
   iii. Bingham & Taylor, #4905

B. Vaults
   i. Strongwell, Model WA00
      a. Size 3' x 5', 2-piece lids

b. Size 4′ x 6′, 3-piece lids

2.2 MATERIALS

A. Valve Boxes and Covers:
   i. Valve boxes and covers shall be of cast-iron manufactured as a unit with all associated extensions and bases.
   ii. Valve boxes shall be 2-piece, screw type, with an inside diameter 5-1/4" shaft.
   iii. Valve boxes shall be adjustable from 18" to 24", and 24" to 36".
   iv. Covers for valve boxes on potable water lines shall have the word "WATER" cast onto the cover. Covers for sewage valves, sludge valves, and non-potable water valves shall have the word "SEWER" cast onto the cover. Covers for natural or manufactured gas valves shall have the word "GAS" cast onto the cover.
   v. Cover shall have two (2) slots for hooks to open top.
   vi. Bottom shall have a flared end to prevent settling.

B. Vaults:
   i. Vaults shall be constructed of reinforced polymer concrete panels manufactured in molded structural shapes.
   ii. Inner surface of vaults shall have a heavy gel coat of polymer resin for a smooth and non-abrasive surface.
   iii. Vaults shall include a one-piece collar to keep the structure square and true to form.
   iv. Vault covers shall be non-locking with the appropriate wording per the utility, i.e., WATER, TELECOMMUNICATION, ELECTRICAL, etc.
   v. Vault covers shall be providing a minimum 8,000 lb. service load over a maximum 10" square area of space.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Valve boxes and vaults shall be inspected prior to installation for any defects, cracks, and that all necessary parts are on hand.

3.2 INSTALLATION

A. Valve Boxes:
   i. Valve boxes shall be installed plumb, centered over the operating nut on a firm and compacted base and carefully and thoroughly backfilled.
   ii. Valve boxes shall be installed so as to not induce stress to the valve.
   iii. Valve boxes shall be installed with the top no more than 1/2-inch above finished grade. Valve boxes shall be installed with the top of the box flush with finished paving.

B. Vaults:
   i. Vaults shall be installed plumb, centered over the valves or equipment on a firm and compacted base and carefully and thoroughly backfilled.
   ii. Valve boxes shall be installed so as to not induce stress to the valve.
   iii. Valve boxes shall be installed with the top no more than 1/2-inch above finished grade. Valve boxes

shall be installed with the top of the box flush with finished paving.

3.3 PROTECTION

A. Valve boxes and vaults shall be protected from damage until final acceptance of the work.

B. Any valve box or vault damaged prior to final acceptance of the work shall be removed and replaced with all costs borne by the Contractor.

END OF SECTION 332664

SECTION 33 26 67
SERVICE CONNECTIONS

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. This section covers the material and installation requirements for service connections.

1.2 RELATED SECTIONS

A. Section 31 2100, Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2660, Water System

1.3 REFERENCES

A. AWWA C800 AWWA Standard for Underground Service Lines, Valves and Fittings

B. ANSI B.1.1 American National Standard for Unified Inch Screw Threads

C. ANSI B.1.20.3 Dry Seal Pipe Threads

D. ASTM B88 ASTM Standard for Seamless Copper Water Tube

E. ASTM B584 ASTM Standard for Copper Alloy Sand Castings for General Applications

1.4 SUBMITTALS

A. The Contractor shall submit product data including catalog cuts, manufacturing data, test reports as outlined in Section 3 of AWWA C800, manufacturer's installation instructions and the manufacturer's certificate of compliance with AWWA C800.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Valve and fitting castings shall be made from Copper Alloy No. C83600 in accordance with ASTM B62 or ASTM B584.

B. Seals, threads, and packing shall be of materials recommended by the manufacturer that are compatible with the valve or fitting.

C. Service lines:

i. Copper service lines shall be seamless Type “K” soft copper conforming to ASTM B-8-62.

ii. Brass material shall be seamless red brass (copper alloy C230) conforming to ASTM B-43.

a. Approved Manufactures:

1. McDonald

2. Merit
3. General Pipe Works

2.2 FABRICATION

A. All service line valves and fittings shall conform to AWWA C800 and shall be manufactured to be first class in every respect.

B. Valves and fittings shall be free of metal chips, filings and excess lubricants.

C. Castings shall be clear and sound without defects.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Service lines shall run in the shortest and straightest possible course from the water main to the meter installation and from the meter installation to the building.

B. Jumbo standard meter boxes shall be plastic (13" x 20" x 12") as manufactured by Carson or approved equal with solid cast iron lid as manufactured by Russell Foundry, or approved equal.

C. Larger meters and detector checks shall require reinforced polymer concrete panel vaults as per Section 33 2664 due to their size, bypass piping, etc.

END OF SECTION 332667

SECTION 33 26 68

FIRE HYDRANTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This specification covers material and installation specifications for fire hydrants and related accessories.

1.2 RELATED SECTIONS

A. Section 31 2100 - Trenching, Backfill and Compaction of Utility Trenches

B. Section 33 2600 - Ductile Iron Pipe and Fittings

C. Section 33 2660 - Water System

D. Section 33 2662 - Gate Valves

E. Section 33 2664 - Valve Boxes and Vaults

1.3 REFERENCES

A. AWWA C502, AWWA Standard for Dry Barrel Fire Hydrants.

B. AWWA C600, AWWA Standard for Installation of Ductile-Iron Water Mains and Appurtenances.

1.4 SUBMITTALS

A. The contractor shall submit to the Engineer in accordance with Section 01300 of these specifications the following items:

i. Design data showing the loss of head and how this test was conducted.

ii. Test reports of the mechanical test and hydrostatic test as defined in Section 5 of AWWA C502.

iii. Product Data.

iv. Manufacturer's Affidavit of Compliance According to Section 5.4 of AWWA C502.

B. The manufacturing process and testing shall be open to and subject to inspection and observation by the Owner's representative.

1.5 DELIVERY, STORAGE AND HANDLING

A. Hydrants shall be complete with all required accessories when shipped. The manufacturer shall prepare hydrants so that they will not be damaged during shipment. Hydrants shall be completely drained and closed prior to shipment.

B. The contractor shall use extreme care when unloading hydrants. Hydrants shall be inspected prior to unloading and checked for damage during shipment. Any hydrant damaged during this unloading or shipping process shall be rejected and removed from the job.

C. The contractor shall provide a dry, suitable area for storage of hydrants. Hydrants shall be protected from freezing and other damages during storage.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

A. American-Darling Valve - Mark 73

B. Mulleur Company – Centuriun

C. M & H - Model 129

D. Clow Valve Company – Medallion

E. U S Pipe Company - Metropolitan 250 M-94

2.2 MANUFACTURED UNITS:

A. All fire hydrants shall consist of a hydrant, gate valve, ductile iron spools and associated accessories and be considered as a unit.

i. Hydrant:

a. Fire hydrants shall conform to AWWA C502.

b. Fire hydrants shall have a working pressure of 150 psi and be tested at 300 psi.

c. Fire hydrants shall have a 4-1/2-inch valve opening.

d. Fire hydrants shall be equipped with two 2-1/2-inch nozzles (thread NOZ GA NS) and one 4-1/2-inch nozzle (thread MOZ GA NS).

e. Fire hydrants shall open counterclockwise and be equipped with a 1-1/2-inch bronze pentagonal operating nut.

f. Fire hydrants shall be equipped with a 6-inch mechanical joint or flange joint shoe complete with gland and rubber gaskets.

g. Fire hydrants shall be equipped with a break away safety flange, brass safety stem coupling and brass safety sleeve.

h. Fire hydrants shall be equipped with double drain valves and double drain openings, "O" ring seals, bronze seat ring with compression type main valve, an oil filled reservoir and a positive stop stem.

i. Nozzle caps shall be provided with non-kinking chains.

j. All fire hydrants shall be manufactured in the United States.

ii. Gate Valves shall comply with Section 02662 of these specifications.

iii. Ductile iron spools shall comply with Section 02600 of these specifications.

2.3 PAINTING

A. Fire hydrant interiors shall be painted to conform with AWWA C502.

B. Fire hydrant exteriors shall be painted to conform with AWWA C502 and in addition shall be painted with red enamel.

2.4 MANUFACTURER'S TEST

A. Fire hydrants shall be subjected to the mechanical test and hydrostatic tests as outlined in Section 5 of AWWA C502.

B. Copies of these tests shall be furnished to the Engineer.

PART 3 – EXECUTION

3.1 EXAMINATION

A. All fire hydrants shall be inspected prior to installation for direction of opening, operating nut dimensions, tightness of all bolts, cleanliness of inlet and all defects or damage during shipping and handling.

B. Defective hydrants shall be removed from the jobsite.

3.2 INSTALLATION:

A. Fire hydrants shall be installed as shown on the plans or directed by the Engineer.

B. All hydrants shall be installed plumb with the 4-1/2 inch pumper nozzle facing the street or alley.

C. Fire hydrants, where placed behind curbing, shall be set back a sufficient distance to avoid car bumpers as the cars pull to the curb. Fire hydrants shall be placed 2-feet from sidewalks and parkways to provide safety for pedestrians.

D. Hydrants shall be set with the breakaway flange not less than 2-inches or more than 6-inches above finished grade.

E. Fire hydrants shall be connected to a supply line 6-inches in diameter or larger.

F. Fire hydrants shall be installed with a gate valve and box located a sufficient distance away from the hydrant to allow for hydrant maintenance.

G. A drainage pit 2-feet x 2-feet x 2-feet shall be excavated below the hydrant and filled with coarse graded stone or gravel to 6-inches above the hydrant opening. The drainage pit shall not be connected to or be near any sewer.

H. All hydrants shall be carefully and thoroughly backfilled.

3.3 CLEANING AND PROTECTION:

A. The contractor shall clean the area of any construction debris, excess backfill and other items.

B. The contractor shall carefully check hydrant for proper operation in the presence of the Engineer.

C. The contractor shall maintain hydrants from damage until final acceptance of the work.

END OF SECTION 332668

SECTION 33 26 70
BACKFLOW PREVENTION

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. This section covers the material and installation requirements for backflow prevention devices.

1.2 RELATED SECTIONS

A. Section 31 2100 - Trenching, Backfill and Compaction for Utility Trenches

B. Section 33 2600 - Ductile Iron Pipe and Fittings

C. Section 33 2660 – Water System

D. Section 33 2666 – Service Connection

1.3 REFERENCES

A. AWWA C506 AWWA Standards for Backflow Prevention Devices. Reduced Pressure Principle and Double Check Valve Types.

B. ANSI/ASSE Spec. No. 1024

1.4 SUBMITTALS

A. The Contractor shall submit, in accordance with Section 01300 of these specifications, product data including catalog cuts, test reports, manufacturer's installation instructions and the manufacturer's certificate of compliance with AWWA C506.

1.5 QUALITY ASSURANCE

A. Backflow prevention devices shall be tested by a laboratory recognized as having expertise in testing backflow prevention devices as required in Section 1.3 of AWWA C506 Specifications. The laboratory shall be acceptable to the Owner.

1.6 DELIVERY, STORAGE AND HANDLING

A. The manufacturer shall prepare each backflow prevention device for shipment so that no damage will occur during shipment.

B. All backflow preventers shall be complete in every respect and completely drained with all openings closed prior to shipment.

C. Upon receipt, the Contractor shall thoroughly examine backflow preventers for damage during shipment and store them in a clean, dry and safe area.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Because of the threat of electrolysis, when differing metals are used, insulation and/or electrolytically similar metals shall be used throughout the construction.

B. Residential dual check valve preventers:

i. Residential dual check valve preventers shall be bronze bodied, with two acetyl resin plastic check modules, BUNA "N" Seals, stainless steel springs, and "O" ring union seals. The dual check valve preventers shall be

Watts No. 7 or an approved equal. All residential dual check valve preventers shall be 3/4 inch or larger.

C. Commercial Double Check Valve and Reduced Pressure Zone Backflow Preventers:

i. Valve bodies, covers, spools and spacers shall be ASTM B61, Bronze, or ASTM A126, Class B, Gray Iron.

ii. Clapper and Poppett Facing Rings shall be molded synthetic rubber with a shore durometer hardness of 35 to 45.

iii. Relief Valve Facing Rings shall be molded synthetic rubber with a shore durometer hardness of 60 to 70.

iv. Swing Pin and Guide Stems shall be ASTM B139, Grade A, C or D Phosphor Bronze or ASTM A 276, Type 304, Stainless Steel.

v. Springs shall be ASTM A313 Steel or ASTM B159 Phosphor Bronze.

vi. Diaphragms shall be synthetic rubber with a cotton or rayon insert conforming to Federal Specification HHP-151B.

vii. Seat Rings and Valve Seats shall be ASTM B61 Bronze or ASTM A276, Type 304, Stainless Steel.

2.2 MANUFACTURED UNIT

A. Backflow Preventers shall be manufactured as a unit capable of operating at a supply pressure of 150 psi and a temperature of 140-degrees F.

B. Residential dual check valve backflow preventers shall meet or exceed ANSI/ASSE Standard 1024.

C. Double check valve and reduced pressure zone backflow preventers shall meet or exceed AWWA C506 Specification.

D. Fabrication:

i. All foundry and machine work shall be first class, free of injurious defects and conform to the manufacturer's tolerances.

ii. Flange joints shall be faced true and machined at right angles to their respective axes. Threaded joints shall be concentric and accurately cut free of burrs.

iii. All joints shall be tested as watertight when subjected to the design pressure.

PART 3 – EXECUTION

3.1 EXAMINATION

A. The Contractor shall examine all backflow preventers for damage prior to installation.

3.2 INSTALLATION

A. All backflow preventers shall be installed on the consumer side of the meter.

B. Small residential backflow preventers shall be installed in the water meter box.

C. Backflow preventers greater than 2" in diameter, shall be installed as shown on the Drawings.

D. All backflow preventers shall be installed with no leakage around any joint.

E. Backflow preventers greater than 2" in diameter shall have blocking castings under them so that their weight is not supported by the adjacent piping.

END OF SECTION 332670

SECTION 33 27 22

GRAVITY SANITARY SEWER SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES:

A. This section of specifications covers installation requirements of gravity sewer pipe and pressure sewer pipe. Testing requirements for gravity sewers, manholes, and force mains are also provided in this section.

B. All materials used in the construction of sewers shall be new and unused when delivered to the job site and shall be suitable for installation and operation under the conditions for which they are to be used.

1.2 RELATED SECTIONS:

A. Section 33 22 50 – Trenching, Backfilling and Compaction

B. Section 33 26 07 – Sanitary Sewer Concrete Manholes

PART 2 – PRODUCTS

2.1 GENERAL:

A. The Contractor shall provide all materials, equipment, and labor necessary to accomplish the work as shown or specified herein.

2.2 MATERIALS:

A. All materials used in the construction of sewers shall be new and unused when delivered to the work and shall be suitable for installation and operation under the conditions for which they are to be used.

B. All sewer pipe and materials used in its manufacture shall be tested and inspected by an approved commercial testing laboratory prior to delivery to the site and all materials which fail to conform to these specifications shall be rejected.

C. After delivery to the site, any materials which have been damaged in transit or are otherwise unsuitable for use in the work shall be rejected and immediately removed from the site. Certified copies in duplicate of the inspection and acceptance reports of the testing laboratory shall be supplied to the Owner's Representative prior to use of these materials.

D. Each joint of pipe delivered to the work shall be stamped or marked to indicate the testing laboratory's acceptance or approval. The cost of inspecting and testing materials shall be borne by the Contractor, and the Owner's Representative shall approve the Laboratory. The Owner's Representative may require laboratory tests of other materials should he consider this necessary to get such materials to comply with the specifications.

E. Certified mill test certificates will be accepted for PVC and DI pipe fittings.

PART 3 – INSTALLATION

3.1 GRAVITY SEWER PIPE LAYING - GENERAL:

A. Before sewer pipe is placed in position in the trench, the bottom and sides of the trench shall be carefully prepared and the necessary bracing and sheeting installed.

B. Unless noted otherwise on the drawings, all gravity sewer lines shall be installed with a minimum thirty-six (36) inches of cover.

C. A properly designed and operated laser beam device may be used to align and grade the pipe. Laser beam devices used shall be carefully calibrated at intervals not to exceed 30 calendar days.
D. Air blowers must be used in conjunction with laser beam devices and must be sufficient to provide an air flow through the pipe of 4 to 6 mph.
E. If approved by the Owner's Representative, the batter board method may be used. A mason's line shall then be tightly stretched above ground level, parallel to and directly above the axis of the pipe to be installed; this line to be supported at intervals not exceeding 50 feet. The exact line and grade for each section of pipe shall be determined by measuring down from this line to the invert of the pipe in place. Each pipe shall be accurately placed to the exact line and grade called for on the plans. The Contractor shall furnish all labor and materials necessary for erecting batter boards.
F. Water shall not be allowed to run or stand in the trench while pipe laying is in progress or before the joints are completed or before the trench has been backfilled. The Contractor shall not open up at any time more trench than his available pumping facilities are able to dewater.
G. Each piece of pipe and special fitting shall be carefully inspected before it is placed and no defective pipe shall be laid in the trench. Pipe laying shall proceed up-grade, starting at the lower end of the grade and with the bells uphill.
H. After pipe laying has begun, it shall continue progressively up-grade. No section of pipe installation will be skipped without a written request for such procedures from the Contractor and approved by the Owner's Representative.
I. Bell holes shall be of sufficient size to allow ample room for properly making the pipe joints. Bell holes shall be cut not more than five joints ahead of pipe laying. The bottom of the trench and the crushed stone cushion between bell holes shall be carefully graded so that the pipe barrel will rest on a solid foundation for its entire length. Each joint shall be laid so that it will form a close concentric joint with adjoining pipe and so as to avoid sudden offsets and inequalities in the flow line.
J. Backfilling of trenches shall be started immediately after the pipe is in place and the joints completed and inspected by the Owner's Representative.
K. A metallic tape or wire shall be installed in the same trench with all non-metallic pipe (PVC) in order that the pipe may be located with electronic metal detection equipment. Wire shall be T.W. 12-gauge solid copper conforming to specifications for annealed copper, ASTM B-3 and Underwriters Laboratories Thermoplastic Insulated Wire Standard No. 83, latest revision. Wire shall be Simplex BW3001, or equal. Pipe detector tape shall be two (2) inch wide minimum metalized tape. Tape shall be Griffolyn Company, Inc., Terratape 2" D., or equal. Wire and/or Tape shall be secured to pipe at intervals of 20 feet.
L. Manholes shall be installed according to Section 33 26 07 – Concrete Manholes.

3.2 LATERALS INSTALLATION:

A. Wyes shall be installed in sanitary sewer lines at all points shown on the plans or specified herein. If such branches are not to be used immediately, they shall be closed with gasketed plugs specifically designed for such purpose.
B. If the work consists of the construction of a sewer that is to replace an existing sewer, all of the existing service lines shall be connected to the new line.
C. Wyes shall be installed in sanitary sewers so as to properly serve each existing house and each vacant lot facing or abutting on the street or alley in which the sewer is being laid, and at such other locations as may be designated by the Owner's Representative. The exact location of each connection shall be determined by the Owner's Representative before backfilling.
D. Should ductile pipe lining be scratched, chipped, or otherwise damaged during the tapping process, it shall be properly repaired or recoated by the Contractor.

E. Laterals shall be bedded and backfilled according to Section 33 22 50 – Trenching, Backfill, and Compaction.
F. Where the depth of cut is over 8 feet or where the grade of a sanitary sewer is lower than necessary to drain abutting property, and when designated by the Owner's Representative, connecting risers shall be installed to serve each existing house and each vacant lot facing or abutting on the street in which the sewer is being laid.
G. Connecting risers shall be either 4 or 6 inches in diameter installed from a wye connection to the elevation designated by the Owner's Representative. The wye or tee connection shall be securely supported by a block of concrete, as shown on the drawings, to support the riser pipe. Open ends of connecting risers shall be closed, as herein before specified for wye branches. Backfilling shall be carefully done around these risers.

3.3 Pressure Sewer Pipe Laying – General
A. Before sewer pipe is placed in position in the trench, the bottom and sides of the trench shall be carefully prepared and the necessary bracing and sheeting installed.
B. Unless noted otherwise on the drawings, all pressure sewers shall be installed with a minimum of thirty-six (36) inches of cover.
C. Water shall not be allowed to run or stand in the trench while pipe laying is in progress or before the joints are completed or before the trench has been backfilled. The Contractor shall not open up at any time more trench than his available pumping facilities are able to dewater.
D. Each piece of pipe and special fitting shall be carefully inspected before it is placed and no defective pipe shall be laid in the trench. No section of pipe installation will be skipped without a written request for such procedures from the Contractor and approved by the Owner's Representative.
E. All pressure pipe 4 inches and over in diameter shall be provided with adequate thrust restraints. Thrust restraints, consisting of concrete thrust blocks and/or mechanical restraining rod attachment shall be furnished at all fittings, plugs, and all pipe bends as shown on the Drawings.
F. Air release valves, Air/Vacuum release valves, and Combination air valves shall be installed at the locations shown on the drawings.
G. A metallic tape or wire shall be installed in the same trench with all non-metallic pipe (PVC) in order that the pipe may be located with electronic metal detection equipment. The tape or wire shall be attached to the top of the pipe. Wire shall be T.W. 12-gauge solid copper conforming to specifications for annealed copper, ASTM B-3 and underwriters Laboratories Thermoplastic Insulated Wire Standard No. 83, latest revision. Wire shall be Simplex BW3001, or equal. Pipe detector tape shall be two (2) inches wide minimum metalized tape. Tape shall be Griffolyn Company, Inc., Terratape 2" D or equal. Wire and/or Tape shall be secured to pipe at intervals of 20 feet.

3.4 PIPE PROTECTION:
A. Sewer pipe which, when completed, will have less than three (3) feet of cover, shall be provided with concrete protection and shall be constructed of ductile iron pipe.
B. Where foundation conditions are not satisfactory, as determined by the Owner's Representative, sewer pipe shall be either laid on a concrete cradle, sand backfill, foundation material, and/or constructed of ductile iron pipe as shown on the plans or as directed by the Owner's Representative.

3.5 TESTING OF GRAVITY SEWERS AND MANHOLES:
A. General:
1. The approval and acceptance of gravity sewer lines and manholes shall be based on final testing. The Contractor must provide a 72-hour notice prior to final testing to the City Owner's

Representative. A representative from the Owner's Representative and/or Owner must be present to witness final testing procedures. Tests performed in the absence of the Owner's Representative's and/or Owner's representatives shall be considered invalid and shall be repeated by the Contractor.

2. Final testing of gravity lines shall only be performed after all work adjacent to and over the pipeline has been completed. Trench backfilling, grading, roadway sub-grade, concrete work, other utility installation, and any other superimposed loads shall be completed and in place prior to final testing.
3. Prior to any testing and final inspection, all gravity lines shall be cleaned of debris and flushed clean with water as necessary by the Contractor. Debris and flush water shall be contained at a lower manhole and removed from the line. Debris and flush water shall not be allowed to enter live existing sanitary sewers. Contractor shall be responsible for collection and proper disposal of debris and flush water.
4. All apparatus and equipment required for testing shall be furnished by the Contractor.
5. Contractor shall provide the Owner's Representative and Owner with copies of all field notes and documentation obtained during final testing.

B. Scope:
   1. All gravity sewers shall be tested by one or more of the following methods as directed by the Owner's Representative and / or the City Owner's Representative:
      a. Direct Visual Inspection by the Owner's Representative.
      b. Exfiltration of water.
      c. Exfiltration of air under pressure (Low Pressure Air Testing)
      d. Video Inspection.
   2. In addition to the above testing requirements, all PVC gravity sewers shall pass mandrel testing to verify roundness and proper installation.
   3. All manholes shall be vacuum tested.

C. Direct Visual Inspection by the Owner's Representative
   1. The Owner's Representative(s) shall visually inspect all gravity sewer pipe installed to verify alignment and ensure the pipe is free from obstructions and debris. Each segment of sewer shall be "flashed" using sunlight and mirrors. When the full diameter of the pipe is visible between adjacent manholes, the segment of pipe is deemed properly aligned and free of sags and debris.
   2. If segment of pipe fails visual inspection, the pipe shall be cleaned and/or replaced and re-tested by the Contractor.

D. Exfiltration of Water
   1. The section of sewer to be tested shall be sealed by inserting inflatable rubber bags or plugs in the pipes or by other means approved by the Owner's Representative. Water shall then be introduced into a manhole until the pipeline section is completely filled. The Contractor shall fill the pipe to the required test level prior to the time of exfiltration testing to permit normal absorption into the pipe walls if concrete or concrete lined ductile iron pipe is being tested. Throughout the test period of two (2) hours minimum, the water level in the upper manhole shall be maintained at least 18-inches above the crown of the upper end of the pipe or at least 18-inches above the groundwater table, whichever is greater. The length of pipe tested shall be limited such that the pressure on the centerline of the lower pipe end tested does not exceed

six (6) feet water column.

2. Exfiltration of water shall not exceed 100-gallons per mile of sewer per inch of inside diameter per 24-hours in any section of the completed work. In no case shall the exfiltration of water exceed 2500 gallons per mile per 24 hours. All observed leaks shall be corrected by the Contractor even though exfiltration is within the allowable limits.
3. The Owner's Representative may direct the Contractor to test selected sections of the sewer in the following manner:
   a. After the selected sections of the sewer are laid in the trench and the joints completed but before any backfill is placed, the Contractor shall install suitable bulkheads or stoppers in each end of the sewer and fill the sewer with water.
   b. The sewer shall be filled through one length of sewer pipe installed vertically at a wye or at the end of the pipe being tested.
   c. Water shall be maintained in the line approximately to the top of the fill pipe until the Owner's Representative can inspect the section of sewer being tested.
   d. Any leaks in the sewer system being tested shall be repaired by the Contractor.
   e. The total amount of sewer thus tested shall not exceed five percent (5%) of the total length of sewer constructed.
   f. Should the results of any of these tests indicate leakage, the Owner's Representative may direct the Contractor to change the methods of construction to reduce the leakage on the remaining part of the work.

E. Exfiltration of Air Under Pressure (Low Pressure Air Testing):
   1. Scope
      a. This recommended practice defines the proper procedures for acceptance testing of installed gravity sewer pipe, using low-pressure air, to provide assurance that the pipe, as installed, is free from significant leaks. Included are requirements for equipment accuracy, safety precautions, line preparation, test method, and minimum holding times. This recommended practice does not cover the testing of manholes. All new pipe shall be low-pressure air tested to insure the integrity of the pipe and joints
      b. Only lines tested after backfilling to final grade will be considered for acceptability. However, this test may also be used by the installer as a presumptive test to determine the condition of the line prior to backfilling. At no time will more than four manhole to manhole reaches of pipe be installed before air testing is performed.
      c. Low Pressure Air Testing shall be conducted in accordance with ASTM C828, C924, F1417 and UBPPA UNI-B-6.
   2. Responsibilities:
      a. Responsibility of the Contractor: Unless otherwise specified, the Contractor shall furnish all the necessary equipment and be responsible for conducting all low-pressure air tests. In addition, the Contractor is responsible for any necessary repair work on sections that do not pass the test. No sealant shall be used in any newly installed sewer without the prior approval of the Owner's Representative. Proper structural repair work will be required by the Owner's Representative or the Owner.
      b. Responsibility of the Owner's Representative: The Owner's Representative and/or a qualified inspector shall witness all low-pressure air tests and verify the accuracy and acceptability of the equipment utilized. The Owner's Representative should inform the Contractor regarding acceptable methods of repair in the event one or more sections fail to pass the low-pressure air test. The Owner's Representative should also report to the Owner regarding the

acceptability of the Contractor's work.

c. Responsibility of the Owner: The Owner shall make a final decision as to the acceptability of the Contractor's work based upon the Owner's Representative's recommendation.

d. Regulatory Agencies: Regulatory Agencies in the State, Federal, and/or local level may be legally entitled to witness any air testing and/or review the results. The Owner or his Owner's Representative should check to see that the low-pressure air test specified for his installation is at least as stringent as those which may be required by such regulatory bodies.

3. Equipment
   a. Air testing shall be performed by the Contractor using equipment manufactured by Cherne Industries, Inc., or approved equal. Equipment used shall meet the following minimum requirements.
   b. Pneumatic plugs shall resist internal testing pressures without requiring external bracing or blocking. However, the Contractor should internally restrain or externally brace the plugs to the manhole wall as an added safety precaution throughout the test. No one shall be allowed in the manhole adjoining a line being tested so long as pressure is maintained in the line.
   c. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected.
   d. To facilitate test verification by inspecting Owner's Representative, all air used shall pass through a single, aboveground control panel.
   e. The aboveground air control equipment shall include a shut-off valve, pressure regulating valve, pressure relief valve, input pressure gauge, and a continuous monitoring pressure gauge having a pressure range from 0 to at least 10 psi.
   f. Three individual hoses shall be used for the following connections:
      i. From the control panel to the pneumatic plugs for inflation.
      ii. From the control panel to the sealed line for introducing the low-pressure air.
      iii. From the sealed line to the control panel for continually monitoring the air pressure rise in the sealed line.
4. Line Preparation
   a. During sewer construction, all service laterals, stubs, and fittings into the sewer test section shall be properly capped or plugged so as not to allow for air loss that could cause an erroneous air test result.
   b. A wetted interior pipe surface is desirable and will produce more consistent test results. Where practical, clean the line with cleaning balls, manufactured by Cherne Industries Incorporated or equal, prior to testing, to wet the pipe surface and eliminate debris.
5. Test Procedure
   a. All pneumatic plugs shall be seal tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to the manufacturer's recommended inflation pressure. The sealed pipe shall be pressurized to 9 PSIG. The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.
   b. After a manhole to manhole reach of the pipe has been backfilled and cleaned, and the pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to manufacturer's recommended inflation pressure. When plugs are being placed, the pipe adjacent to the manhole shall be visually inspected to detect any evidence of shear in the pipe due to differential settlement between the pipe and the manhole.
   c. Low pressure air shall be slowly introduced into this sealed line until the internal air pressure

reaches 4.0 PSIG greater than the average back pressure of any groundwater above the pipe, but not greater than 9.0 PSIG. If groundwater is present, refer to the following Paragraph 6. Determination of Groundwater Elevation and Air Pressure Adjustment , of Section 3.5.F in this Specification.

d. After a constant pressure of 4.0 PSIG (greater than the average groundwater back pressure) is reached, the air supply shall be throttled to maintain the internal pressure for at least 2 minutes.
e. When the pressure has stabilized at 4.0 PSIG, the air hose from the control panel to air supply shall be shut off or disconnected. The continuous monitoring pressure gauge shall then be observed while the pressure is decreased to no less than 3.5 PSIG. At a reading of 3.5 PSIG, or any convenient observed pressure reading between 3.5 PSIG and 4.0 PSIG, timing for the test may begin.
f. The portion of line being tested shall be termed "Acceptable" if the allocated line pressure decreases less than one PSI in the time shown for the given diameters and lengths in the following tables.
g. SPECIFIED TfME TABLES: To facilitate the proper use of this recommended practice for air testing, the following tables are provided. Table I contains the specified minimum times required for a 1.0 psig pressure drop from a starting pressure of at least 3.5 psig greater than the average back pressure of any groundwater above the pipe's invert. Table II contains specified minimum times required for a 0.5 psig pressure drop from a starting pressure of at least 3.5 psig greater than the average back pressure of any groundwater above the pipe's invert. Both Tables also include easy to use formulas for calculating required test times for various pipe sizes and odd lengths. Consult the City Owner's Representative for test lengths greater than those provided.

TABLE I

Specification time required for a 1.0 psig pressure drop for size and length of pipe indicated for q = 0.0015

l Pipe Diameter (inches)	2 Minimum Time (min:sec)	3 Length for Minimum Time (ft)	4 Time for Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	3:46	597	.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	I I:20	11 :24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692 L	17:00	I 9:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	I 0.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306 L	28:51	43:16	57:41	72:07	86:32	I 00:57	115:22	129:48
30	28:20	80	21.366L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:I0	72	25.852 L	43:05	64:38	86:10	107:43	129:I6	150:43	172:21	193:53

36	34:00	66	30.768 L	51:17	76:55	102:34	128:I 2	153:50	179:29	205:07	230:46

TABLE II

Specification time required for a 0.5 psig pressure drop for size and length of pipe indicated for q = 0.0015

1	2	3	4	Specification Time for Length (L) Shown (min:sec)							
Pipe Diameter (inches)	Minimum Time (min:sec)	Length for Minimum Time (ft)	Time for Longer Length (sec)	100 ft	I50 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	1:53	597	.190 L	1:53	1:53	1:53	1:53	1:53	I:53	1:53	1:53
6	2:53	398	.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	1 I :24	12:50
15	7:05	159	2.67 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235 L	9:55	13:05	17:27	21:49	26: I	30:32	34:54	39:16
24	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653 L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	46:54
30	14:10	80	10.683 L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12.926 L	21:33	32:19	43:56	53:52	64:38	75:25	86:10	96:57
36	17:00	66	15.384 L	25:39	38:28	*5*I :17	64:06	76:55	89:44	102:34	115:23

h. If there has been no leakage (0 PSIG drop) after one hour of testing, the test section shall be accepted and the test complete. If there is any pressure drop, the complete test shall be run to determine whether or not the test section is acceptable.
i. If the pressure drops 1.0 PSIG before the appropriate time shown in the table has elapsed, the air loss rate shall be considered excessive and the section of pipe has failed the test.
j. If the section fails to meet these requirements, the Contractor shall determine the source(s) of leakage, and he shall repair or replace all defective materials and/or workmanship to the satisfaction of the Engineer. The extent and type of repair which may be allowed, as well as results, shall be subject to the approval of the Engineer. The completed pipe installation shall then be retested and required to meet the requirements of this test.

6. Determination of Groundwater Elevation and Air Pressure Adjustment

a. In areas where ground water is known to exist, the Contractor shall install a ½-inch diameter capped pipe nipple, approximately 10 inches long, through the manhole wall directly on top of one of the sewer lines entering the manhole. A permanent, watertight seal shall be provided around the pipe nipple at the manhole wall. This shall be done at the time the sewer line is installed.
b. Immediately prior to the performance of the air testing, the ground water shall be determined by removing the pipe cap, blowing air through the pipe nipple into the ground so as to clear it, and then connecting a clear plastic tube to the nipple. The plastic tube shall be held vertically and a measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in this plastic tube. The height in feet shall be divided by 2.31 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11-1/2 feet, then the added pressure will be 5 psig. This will increase the 3.5 psig (mentioned in item e above) to 8.5 psig, and the 2.5 psig to 7.5 psig.)
c. The allowable pressure drop of 1.0 PSIG and the timing in the previous table are not affected and shall remain the same.
d. In no case shall the starting test pressure exceed 9.0 PSIG. If the average vertical height of groundwater above the pipe invert is more than 12.7 feet, the section so submerged may be tested using 9.0 PSIG as the starting test pressure.
e. After determining the air pressure adjustment, the test shall resume according to Item 5 - Test Procedures stated above.
f. After determining groundwater height, each pipe nipple shall be recapped and sealed to prevent future infiltration.

F. Video Inspection:
1. Prior to final acceptance, the sewer installation shall be video inspected by the Contractor's forces as per the Owner's standard requirements. This shall be in addition to any City / municipal CCTV requirements. Said inspection shall verify locations of service connections, and locations of possible defects/infiltration. Any defects found shall be repaired by the Contractor in a manner acceptable to the Owner.

G. Mandrel Testing:
1. Mandrel test (deflection test) shall be performed by the Contractor in order to verify the roundness and proper installation of the PVC gravity sewer line.
2. Equipment systems used to perform mandrel tests shall be specifically designed for the pipe material being tested. Mandrels that do not specifically state the size and type of piping for which it is applicable shall not be allowed.
3. Deflection Test:
a. The deflection test shall consist of testing PVC gravity sewer pipe for proper installation by the method outlined (see ASTM D3034). The testing shall be accomplished prior to final acceptance, but at least 30 days after the pipe has been backfilled completely to permit stabilization of the soil-pipe envelope.
b. After the pipeline has been installed and backfill materials have been compacted to their required standard densities, the mandrel shall be pulled by hand through the pipeline with a suitable rope or cable that is connected to an eyebolt at one end of the gauge. A similar rope or cable shall be attached to the eyebolt at the opposite end of the mandrel and tension shall be applied to it. This will insure that the mandrel maintains its correct position during testing and also to remove the mandrel if it should become lodged in an excessively deflected pipeline. Winching or other mechanical means of forcing the mandrel through the pipeline is unacceptable. Pipeline deflection testing shall have a deflection not exceeding 5% of the

base inside pipe diameter as established by ASTM Standards D3034 and F679.

c. Permanent record of all testing with locations where excessive pipeline deflections occur shall be kept by the Contractor and forwarded to the Engineer after completion of testing on each line.
d. The Contractor shall immediately correct or replace all sections of pipe which deflect more than 5%.
e. All material and labor required for testing and/or replacement of pipelines shall be furnished by the Contractor.
f. Pipelines requiring correction and/or replacement shall be retested after an additional 30 day backfill stabilization period.

H. Manhole Vacuum Testing:
1. Vacuum tests shall be conducted on newly constructed manholes. Preliminary manhole testing shall take place following construction after all connections are made, and before backfilling. Test results derived from this test will allow time for necessary repairs to be completed before further construction proceeds and hinders such repairs. Final tests must be performed after the manhole has been backfilled.
2. Equipment:
a. Manhole vacuum tester assembly and vacuum pumps shall be manufactured by Cherne Industries, Inc., or approved equal.
b. Pneumatic plugs shall be manufactured by Cherne Industries, Inc. or approved equal. These plugs shall have a sealing length equal to or greater than the diameter of the connecting pipe to be sealed.
3. Procedures:
a. Plug all manhole entrances and exits other than the manhole top access using suitably sized pneumatic or mechanical pipeline plugs and follow all manufacturer's recommendations and warnings for proper and safe installation of such plugs. Plugs should be inserted a minimum of 6" beyond manhole wall. Make sure such plugs are properly rated for the pressures required for the test. The standard test of 10" Hg. (mercury) is equivalent to approximately 5 PSIG (0.3 bar) backpressure. Unless such plugs are mechanically restrained, it is recommended that the plugs are used with a minimum of two times (2x) safety factor or a minimum of 10 PSIG (0.7 bar) backpressure usage rating.

CAUTION: BRACE INVERTS IF LINES ENTERING THE MANHOLE HAVE NOT BEEN BACKFILLED TO PREVENT PIPE FROM BEING DISLODGED AND PULLED INTO THE MANHOLE.

b. Any other openings such as lifting holes shall be sealed with an approved non-shrink grout.
c. Install the vacuum tester head assembly at the top of the manhole. Adjust the cross brace to insure that the inflatable sealing element inflates and seals against the straight top section of the manhole or the ring assembly, if possible. (If using a "plate" style manhole tester, position the plate on the manhole ring assembly).
d. Attach the vacuum pump assembly to the proper connection on the test head assembly. Make sure the vacuum inlet/outlet valve is in the closed position.
e. Following safety precautions and manufacturer's instructions, inflate sealing element to the recommended maximum inflation pressure.

CAUTION: DO NOT OVER INFLATE.

f. Start the vacuum pump and allow pre-set RPM to stabilize.

g. Open the inlet/outlet ball valve and evacuate the manhole to 10" Hg. (approximately negative 5 PSIG, 0.3 bar).
   CAUTION: DO NOT PRESSURIZE MANHOLE! THIS MAY RESULT IN MANHOLE DAMAGE AND/OR RESULT IN MANHOLE TEST HEAD DISLODGING FROM MANHOLE INLET!
h. Close vacuum inlet/outlet ball valve and monitor vacuum for specified test period (see table). If vacuum does not drop in excess of 1" Hg., manhole is considered acceptable and the manhole passes the test. If manhole fails the test, Contractor shall complete necessary repairs and repeat test procedures until satisfactory results are obtained.

Minimum Test Times for Various Manhole Diameters

depth – feet	Manhole diameter – inches			
	48	60	72	96
8	20 sec	26 sec	33 sec	38
10	25 sec	33 sec	41 sec	48
12	30 sec	39 sec	49 sec	57
14	35 sec	46 sec	57 sec	67
16	40 sec	52 sec	67 sec	76
18	45 sec	59 sec	73 sec	86
20	50 sec	65 sec	81 sec	95
+ 2 ft incr.	+5 sec	+6.5 sec	+8.0 sec	+9.5 sec

(The values listed above are based upon ASTM Specification C1244 "Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test".)

4. Repeat the above test procedure after backfilling manhole for final acceptance test.
5. All manholes that fail the test or have visible leaks, even if they pass the test, shall be repaired or replaced by the Contractor until the manholes pass the test, to the complete satisfaction of the Owner's Representative and / or the City Engineer. Manholes that have any visible leaks will not be accepted.

END OF SECTION 332722

SECTION 33 27 29

THRUST RESTRAINT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. All pressure pipe 2-inches and over in diameter shall be provided with adequate thrust restraints. Thrust restraints, consisting of concrete thrust blocks and/or mechanical restraining rod attachment shall be furnished at all hydrants, valves, fittings, plugs, and all pipe bends 11-1/4-degrees or greater.

B. Concrete used for thrust backing shall be 3000 psi min. Concrete thrust blocks shall be poured against undisturbed earth having sufficient bearing strength to support the thrust load.

C. Tie rods and clamps shall be installed where shown on the drawings and as needed. Tie rods and clamps shall be of an approved design and shall be protected against corrosion by a field coat of bituminastic coating hand applied before and after installation.

D. Thrust blocking shall comply with the charts outlined in the standard details and adjusted for pressures or soil bearing strengths that differ from those used in the chart.

1.2 PAYMENT

A. No separate payment shall be made for thrust restraint. All costs shall be incidental to the ductile iron fittings.

END OF SECTION 332729

SECTION 33 31 13

POLYVINLY CHLORIDE (PVC) GRAVITY SEWER PIPE

PART 1 – GENERAL

1.1 SUMMARY

A. This section of specifications covers the material and installation requirements for polyvinyl chloride (PVC) pipe, fittings, and laterals for use in gravity sewer applications.

1.2 RELATED SECTIONS:

A. Section 31 2100 – Trenching, Backfilling, and Compaction of Utility Trenches

B. Section 33 2605 – Precast Concrete Manholes

1.3 REFERENCES

A. ASTM D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

B. ASTM D3034 – Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

C. ASTM D2412 – Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

D. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

E. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

F. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

G. AWWA C900 – Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 inches – 12 inches, for Water Distribution.

1.4 QUALITY ASSURANCE

A. All piping and appurtenances installed by the Contractor shall be new and unused. All PVC pipe shall be properly stored at the manufacturer to prevent degradation of the pipe due to exposure to sunlight and excessive heat. Pipe which has been stored by the Contractor for three (3) months or longer shall not be acceptable.

B. Pipe shall be handled, transported, delivered, and stored by methods that will not damage the pipe. The load shall be so supported that the bottom rows of pipe are not damaged by "egging" or crushing. Pipe shall be unloaded carefully and strung or stored as close to the final point of placement as is practical. Pipe shall not be stored outside where subject to sunlight. Any pipe damaged or bent will be rejected and shall be replaced by the Contractor at no additional cost to the project.

C. All pipe and fittings shall be inspected at the factory and on the job site. Then pipe shall be homogeneous throughout and free from cracks, holes, foreign inclusions, or other defects. The pipe

shall be as uniform in color as commercially practical. PVC pipe shall have a ring painted around the spigot ends in such a manner as to allow field checking of setting depth of pipe in the socket.

D. PVC sewer pipe shall be marked with the manufacturer's name, production lot number, ASTM designation, PVC cell classification or material code, dimension ratio or standard dimension ratio, and the nominal diameter. All PVC pipe shall be manufactured in the United States.

PART 2 – MATERIALS

2.1 PVC GRAVITY SEWER:

A. PVC gravity sewer pipe shall be made from compounds conforming to ASTM D1784. PVC pipe and fittings, 8 to 12 inches in diameter, shall conform to and be tested under all of the requirements of ASTM D3034. This designation specifies minimum requirements and test methods for materials, dimensions, workmanship, flattening resistance, impact resistance, pipe stiffness, extrusion quality, and pipe marking. PVC gravity sewer shall have a wall thickness equal to or greater than SDR 26.

B. Minimum pipe stiffness (F/ΔY) at 5 percent deflection shall be 115 for all sizes when calculated in accordance with ASTM D2412.

C. PVC Sewer pipe shall be supplied in standard lengths of at least 12 feet 6 inches. Longer lengths are permitted. PVC gravity sewer pipe shall be green in color.

D. Fittings for service connections shall be of the factory-made inline type conforming to the requirements of ASTM D3034 and shall have a wall thickness equal to or greater than SDR 26. Service connections shall be made with wye fittings. Saddle type fittings shall not be used.

E. All pipe and fittings shall be joined by means of an integral wall bell and spigot with a flexible watertight elastomeric seal. Joint material and testing requirements shall conform to ASTM D3212 and ASTM F477.

2.2 PVC LATERALS:

A. PVC service laterals for PVC sewer mains shall be of same material described in Part 2, A.1 above.

B. PVC service laterals for ductile iron sewer mains shall be AWWA C-900 pipe and shall have a wall thickness equal to or greater than DR 25.

C. Contractor shall provide an easily removable, watertight and airtight, gasketed plug at the end of the service lateral.

PART 3 – EXECUTION

3.1 PVC GRAVITY SEWER:

A. In addition to the requirements for installation and testing specified in Section 33 2661 (Gravity Sanitary Sewer), installation of PVC gravity sewer pipe shall conform to ASTM D2321 and the manufacturer's recommendations unless otherwise amended in these Specifications.

B. Trenching, backfill, and compaction shall conform to Section 31 2100 (Trenching, Backfill, and Compaction of Utility Trenches) of these Specifications.

C. The inside of all bells and outside of all spigots shall be wiped to remove all dirt, water, or other foreign matter so that their surfaces are clean and dry when the pipes are joined.

D. Immediately before joining PVC pipe, the joining surfaces shall be completely coated by brushing with the lubricant sealer furnished by the pipe manufacturer. The spigot end shall then be centered to exact line and grade and then sealed by forcing the spigot into the bell in an approved manner.

E. Pipe that has been field cut must be beveled for insertion into the gasketed joint. Bevel can be made with hand or power tool. In either case, the finished bevel should be the same as the factory bevel.

3.2 PVC LATERALS

A. In addition to the requirements for installation and testing specified in Section 33 2661 (Gravity Sanitary Sewer), installation of PVC lateral pipe shall conform to ASTM D2321 and manufacturer's recommendations unless otherwise amended in these specifications. Connection between service lateral and sewer main shall be watertight. PVC service laterals shall be installed for each lot and extend from the collector sewer to user's property line.

B. Trenching, backfill, and compaction shall conform to Section 31 2100 (Trenching, Backfill, and Compaction of Utility Trenches) of these Specifications.

C. A PVC coated electronic service marker shall be located 6 inches above the top of the lateral just beyond the curb.

END OF SECTION 333113