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SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325 (2017) Steel Construction Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01 (2023; with Change 1, 2023) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 1598 (2021; Reprint Jun 2021) Luminaires

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for seismic protection measures described in this section to the electrical equipment and systems listed below. Structural requirements are in accordance with Section 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT.

1.2.2 Electrical Equipment

Include the following items to the extent required on the drawings or in other sections of these specifications:

Light Fixtures
Switchboards (Floor Mounted)
Transformers

1.2.3 Contractor Designed Bracing

Submit copies of the Design Calculations with the Drawings. Calculations must be approved, certified, stamped and signed by a Registered Professional Engineer. Verify the capability of structural members to

which bracing is attached for carrying the load from the brace. Design the bracing in accordance with [UFC 3-301-01](#) and additional data furnished by the Contracting Officer. Accomplish resistance to lateral forces induced by earthquakes without consideration of friction resulting from gravity loads. [UFC 3-301-01](#) uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas are required. Loadings determined using [UFC 3-301-01](#) are based on strength design; therefore, use [AISC 325](#) for the design. Develop the bracing for the following electrical equipment and systems: (light fixtures, transformers, and switchboards).

1.2.4 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than [2-1/2 inches](#) trade size. Seismically protect all other interior conduit as specified.

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals must be complete in detail, indicating thickness, type, grade, class of metal, and dimensions; and must show construction details, reinforcement, anchorage, and installation with relation to the building construction. Submit copies of the design calculations with the detail drawings. Calculations must be stamped by a registered engineer and must verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: (transformer and Switchboards) to be furnished under this contract must be constructed and assembled to withstand the seismic forces specified in [UFC 3-301-01](#). Entirely locate each item of rigid electrical equipment and rigidly attach on one side only of a building expansion joint. Provide items such as piping, electrical conduit, which cross the expansion joint with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

1.3.2 Nonrigid or Flexibly-Mounted Equipment

The following specific items of equipment to be furnished: (light fixtures) must be constructed and assembled to resist a horizontal lateral force of 1.5 times the operating weight of the equipment at the vertical center of gravity of the equipment.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section [01 33 00](#) SUBMITTAL PROCEDURES:

[SD-02 Shop Drawings](#)

[Lighting Fixtures in Buildings; G, R0](#)

Equipment Requirements; G, R0

SD-03 Product Data

Lighting Fixtures in Buildings; G, R0

Equipment Requirements; G, R0

Contractor Designed Bracing; G, R0

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Provide lighting fixtures and supports conforming to [UL 1598](#).

2.2 SWAY BRACING MATERIALS

Provide sway bracing materials (e.g. rods, plates, rope, angles, etc.) as specified in Section [13 48 73](#) SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Brace conduit as for an equivalent weight pipe in accordance with Section [23 05 48.19](#) SEISMIC BRACING FOR HVAC.

3.2 LIGHTING FIXTURES IN BUILDINGS

Provide lighting fixtures and supports conforming to the following:

3.2.1 Pendant Fixtures

Provide pendant fixtures conforming to the requirements of [UFC 3-301-01](#).

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fixtures

Provide seismic protection for the fixtures conforming to the requirements of [UFC 3-301-01](#). Recessed lighting fixtures not over [56 pounds](#) in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Provide lock or screw attachments for fixture accessories, including louvers, diffusers, and lenses.

3.2.2.2 Surface-Mounted Fixtures

Provide seismic protection for the fixtures conforming to the requirements of [UFC 3-301-01](#).

3.2.3 Assembly Mounted on Outlet Box

Design a supporting assembly, that is intended to be mounted on an outlet box, to accommodate mounting features on [4 inch](#) boxes, plaster rings, and fixture studs.

3.2.4 Wall-Mounted Emergency Light Unit

Design and secure attachments for wall-mounted emergency light units for the worst expected seismic disturbance at the site.

3.2.5 Lateral Force

Provide structural requirements for light fixture bracing in accordance with Section 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT.

-- End of Section --

SECTION 26 05 73

POWER SYSTEM STUDIES

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1584	(2018; E 2019) Guide for Performing Arc-Flash Hazard Calculations
IEEE 1584.1	(2022) Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study
IEEE 3002.2	(2018) Recommended Practice for Conducting Load-Flow Studies and Analysis of Industrial and Commercial Power Systems
IEEE 3002.3	(2018) Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-560-01	(2017; with Change 2, 2019) Operations and Maintenance: Electrical Safety

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: the low-voltage service lateral from each of the utility service distribution transformers to the service entrance equipment and service disconnecting means; the low-voltage distribution system (e.g., panelboards) within each building; to the last overcurrent protection device serving each load (e.g., fused disconnect switches or branch circuit breakers in panelboards).

1.3 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Field Examination Plan; G, R0

Arc Flash Label Formats; G, D0

SD-06 Test Reports

Field Examination; G, D0

SD-07 Certificates

System Analyzer; G, R0

SD-11 Closeout Submittals

Model Files; G, R0

Load Flow Study; G, D0

Fault Current Study; G, D0

System Coordination Study; G, D0

Arc Flash Hazard Study; G, D0

1.4 QUALITY ASSURANCE

1.4.1 System Analyzer

The [System Analyzer](#) must perform the power system studies. The System Analyzer must be a registered professional electrical engineer with a minimum of 3 years of experience with power system studies. Include a list of three comparable jobs performed by the System Analyzer with specific names and telephone numbers for reference. Include the license number and state of the registered Professional Engineer.

1.4.2 System Verifier

The System Verifier may inspect and record settings, markings, and otherwise document the existing equipment. The System Verifier may also place appropriate hazard labels on equipment. The System Verifier must not make any calibrations or adjustments or place equipment into service. When working with energized equipment, the system verifier must be a Qualified Person per [NFPA 70E](#) or working under the direct supervision of a Qualified Person.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 FIELD EXAMINATION

For each pre- and post-study inspection, submit a [field examination plan](#) identifying which facilities must be examined to complete the required work. Include a complete information verification procedure, where Qualified Personnel will be required, PPE requirements for "live"

equipment examinations, and equipment to be used within the limited approach boundary of the equipment.

3.1.1 General

Perform field inspections of the site and equipment before the first study and after the last study to determine the state and settings of the equipment and to verify the final settings agree with the studies. Perform the post-study inspection(s) after changing settings, after performing acceptance tests, and before placing equipment in service.

Schedule the field examination by the System Verifier with the Contracting Officer at least 10 business days before conducting examination. Furnish all materials, labor, and equipment necessary to conduct the examination. Maintain a written record of the all equipment examined, equipment location, equipment ratings, settings, personnel involved, and the date the examination was performed. Submit the written record of each [field examination](#).

3.1.2 Safety

Where examination of the equipment requires energized equipment to be opened, provide a Qualified Person to directly supervising any non-Qualified Person within the hazard area. Use PPE, protective barriers, danger signs and other safety devices to protect and warn personnel in the vicinity of "live" equipment being examined.

3.1.3 Application of Arc Flash Labels

Install arc flash warning labels using Qualified Personnel as necessary after the setting and inspection is complete. For new or modified equipment, install labels before the equipment is energized for the first time after installation/modification or setting changes. Schedule the label placement with the Contracting Officer at least 5 business days before label placement. Furnish all materials, labor, and equipment necessary to place the labels. Maintain a written record of the all equipment that received labels, personnel involved, and the date labels were placed.

3.2 POWER SYSTEM STUDIES

Perform power system studies to demonstrate that the equipment selected and system constructed meet the contract requirements for fault current and interrupt ratings, coordination, protection, and Arc Flash Hazard. Submit reports of the studies along with protective device equipment submittals. Apply Arc Flash Hazard labels to equipment after the studies are approved. Update and resubmit the studies after any changes to the equipment or systems which may affect the study results, and re-apply Arc Flash Hazard labels to equipment after the resubmitted studies are approved. The Government is not responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices or labels ordered and/or procured before approval of the study.

3.2.1 Scope of Studies

The scope of the studies must begin at the utility service entrance of a building and extend down to load buses/panels where the fault current is 2,000 amperes or less (symmetrical) for distribution buses nominally

operating at 208 volt AC and above.

The "source bus" is the source of energy for system being analyzed. This may be the energy feed from a utility, the first bus upstream of the work, generators within the work or upstream of the work, or any other source capable of contributing significant energy into the system being analyzed.

In the systems model for the studies, incorporate all existing and new equipment within the scope of the studies. Incorporate any additional sources or load equipment necessary to accurately model the system's performance.

3.2.2 Determination of Facts

Obtain the available fault current from the owner of the source bus.

3.2.3 Single Line Diagram

Provide a single line diagram showing the electrical system buses, devices, transformation points, and all sources of load current and fault current, including generator and motor contributions. Provide a diagram from the system model. Each bus, device or transformation point must have a unique identifier. Show the location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

The naming of existing components within the system model and single line diagram must match existing installed equipment names. The naming of new components within the system model and single line diagram must use unique identifiers and be coordinated with the Government.

3.2.4 Load Flow Study

Perform the load flow study in accordance with IEEE 3002.2 to identify initial steady-state conditions for the fault current study. For each operating scenario, provide load flow results on the diagram or in the report. Show or describe the loading factors and assumptions used in each operating mode.

3.2.5 Fault Current Study

Use the results of the load flow study to perform the fault current study in accordance with IEEE 3002.3. Provide balanced three-phase fault, bolted line-to-line fault, and single line-to-ground fault current values at each voltage transformation point and at each power distribution bus. For each location, show in tabular form on the diagram or in the report the maximum and minimum available fault currents of all modes of operation for that location.

Describe how the fault contribution from the source bus was determined and why this method is reasonable for the study.

3.2.6 System Coordination Study

Use the results of the load flow study and fault current study. For normal modes of operation, demonstrate that selectivity has been obtained between the devices within the scope of the project. Demonstrate the equipment, machines, and conductors are protected from damage from overloads and fault conditions. Include a description of the coordination

of the protective devices in this project. Provide a written narrative describing which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations; coordination between upstream and downstream devices; and relay settings. Provide recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction). Provide composite coordination plots on a log-log scale. Where recommendations are provided to improve or enhance system reliability, provide separate coordination plots on log-log scale showing the system coordination before and after the implementation of the recommendations. Where coordination has been adjusted to lower arc flash values, include a discussion of the change and the impact on the system within the report.

3.2.7 Arc Flash Hazard Study

Perform the arc flash hazard study in accordance with [IEEE 1584.1](#). Utilize the data from the fault current study to determine the worst case incident energy per [IEEE 1584](#) and OSHA 29 CFR 1910.269 Appendix E. Use identified modes of operation to determine the worst case arc flash energy. If not included in another study, include a description of the devices and device settings for the operating modes that provided the highest arc flash energy. The use of a "maintenance switch" to temporarily reduce the Arc Flash incident energy for maintenance work is acceptable. Where the adjusting the coordination of devices to obtain lower arc flash values, include a discussion of the change and the impact on the system within the report.

3.2.8 Study report(s)

- a. Include a narrative describing the studies performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. Include descriptive and technical data for existing devices and new protective devices proposed. Include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices. For existing devices, included statements on the condition of the equipment based upon field inspections and owner's statements and reports.
- c. Document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings. Identify all assumptions about the protection devices, equipment, and system where data was not available.
- d. For each bus in the system, provide fully coordinated composite time-current characteristics (TCC) curves as required to ensure coordinated power system protection between protective devices and equipment. In a tabular format, provide recommended ratings and settings of all protective devices.
- e. Provide an arc flash study report in accordance with [IEEE 1584.1](#).
- f. Provide the calculations performed for the studies, including computer programs utilized. Provide the name of the software package, developer, and version number.

3.2.9 Arc Flash Labels

Provide arc flash warning labels on electrical equipment likely to require examination, servicing, or maintenance while energized. Typical types of equipment include pad-mounted transformers, switchgear, switchboards, panelboards, disconnect switches, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies. The arc flash label naming must match the naming used in the system modeling and the single line diagram.

Comply with the label requirements specified in [UFC 3-560-01](#). Obtain approval of [arc flash label formats](#) before printing.

- a. Provide a [3.5 inch x 5 inch](#) to [4 inch x 6 inch](#) thermal transfer type label of high adhesion polyester for each location device analyzed. The label must remain in place and be legible for at least 5 years in the installed environment.
- b. Labels must be machine printed with no field markings. Provide arc flash labels in the following manner. All labels must be based on implemented overcurrent devices and settings.
 1. Provide at least one arc flash label for each 480 volt and 208 volt panelboards.
 2. Provide at least one arc flash label for each low voltage (less than 1000 V) switchboard.
 3. Where the equipment construction has different hazards levels in different areas, provide a single label representing the worst case hazard for all branch circuits and a separate unique label for the compartment containing the main protective device. On the worst case label, indicate which branch circuit compartments have the worst case hazard.
- c. Use the worst case hazard of all operating scenarios unless mitigation procedures are used. If mitigation procedures are used, explain the procedures on the label.

Arc Flash label values shall include the following information:

- a. Panel Name
- b. Power Source
- c. Nominal System Voltage
- d. Available fault current at the equipment overcurrent protective devices
- e. The clearing time of overcurrent protective devices based on the available fault current at the equipment.
- f. The date the label was applied.

3.3 MODELING

Develop a software model of the electrical system identified in the scope

of the studies. Develop the model with accurate, verified information. Model existing electrical equipment, machines, devices, and conductors directly connected to, altered by, or otherwise affected by the work. This includes, but is not limited to generators, transformers, switchgear, switchboards, panelboards, motor control centers, motors, voltage regulators, tap changers, protective relays, circuit breakers, switches, fuses, conductors, capacitors, reactors, grounding system, and control equipment.

Provide the final [model files](#) in their native editable formats for future use by the Government. Include device information for devices not in the software vendor's standard distribution.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1 (2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1 (2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3 (2020) American National Standard for Electrical Metallic Tubing (EMT)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2021) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
ANSI/NEMA OS 1	(2013) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
ANSI/NEMA OS 2	(2013) Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 2	(2018; ERTA 1-2 2018) Cable Tray Installation Guidelines
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2021) Wiring Devices Dimensions Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National Electrical Code
- NFPA 70E (2024) Standard for Electrical Safety in the Workplace
- NFPA 780 (2023) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

- TIA-568.1 (2020e) Commercial Building Telecommunications Infrastructure Standard
- TIA-569 (2019e; Add 1 2022) Telecommunications Pathways and Spaces
- TIA-607 (2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

- 10 CFR 431 Energy Efficiency Program for Certain Commercial and Industrial Equipment
- 29 CFR 1910.147 The Control of Hazardous Energy (Lock Out/Tag Out)
- 29 CFR 1910.303 Electrical, General

UNDERWRITERS LABORATORIES (UL)

- UL 1 (2005; Reprint Jan 2022) UL Standard for Safety Flexible Metal Conduit
- UL 6 (2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
- UL 20 (2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
- UL 44 (2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
- UL 50 (2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
- UL 67 (2018; Reprint Aug 2023) UL Standard for Safety Panelboards
- UL 83 (2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
- UL 98 (2016) UL Standard for Safety Enclosed and

Dead-Front Switches

UL 360	(2013; Reprint Apr 2023) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint May 2023) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Apr 2023) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 854	(2020; Reprint Jan 2022) Standard for Service-Entrance Cables
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 943	(2016; Reprint Sep 2023) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors

UL 1004-1	(2012; Reprint Nov 2020) UL Standard for Safety Rotating Electrical Machines - General Requirements
UL 1063	(2017; Reprint Jun 2022) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Aug 2022) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1660	(2019; Reprint Jan 2022) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2017; Reprint Feb 2022) UL Standard for Safety Arc-Fault Circuit-Interrupters

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.3 RELATED REQUIREMENTS

Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS applies to this section, with the additions and modifications specified herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G, R0

Transformers; G, R0

Cable Trays; G, R0

Marking Strips Drawings; G, R0

SD-03 Product Data

Receptacles; G, R0

Special Purpose Receptacles; G, R0

Circuit Breakers; G, R0

Switches; G, R0

Disconnect Switches; G, R0

Elevator Control Disconnect Switches; G, R0

Transformers; G, R0

Enclosed Circuit Breakers; G, R0

Motor Controllers; G, R0

Manual Motor Starters; G, R0

Metering; G, R0

Telecommunications Grounding Busbar; G, R0

Surge Protective Devices; G, R0

Cable Trays; G, R0

Conduit and Fittings; G, R0

Outlet Boxes, Pull Boxes and Junction Boxes; G, R0

Device Plates; G, R0

Wires and Cables; G, R0

Splices and Termination Components; G, R0

Combination Expansion/Deflection Couplings; G, R0

Retractable Power Cord Reel; G, R0

Floor Outlet Boxes; G, R0

SD-06 Test Reports

600-volt Wiring Test; G, R0

Grounding System Test; G, R0

Transformer Tests; G, R0

Ground-fault Receptacle Test; G, R0

Arc-fault Receptacle Test; G, R0

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G, R0

Metering, Data Package 5; G, R0

1.5 QUALITY ASSURANCE

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated. NECA NEIS 1 shall be considered the minimum standard for workmanship.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

- a. Single line diagram of the "as-built" building electrical system.
- b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

- c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.7 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and to Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40 in accordance with NEMA TC 2, UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(40 mils thick).

2.2.6 Flexible Metal Conduit

UL 1, limited to 6 feet. Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet. Provide liquidtight flexible metallic conduit

with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquidtight flexible metallic conduit are specifically designed for such conduit.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.2.10 Combination Expansion/Deflection Couplings

UL 514B. Combination expansion/deflection Couplings shall be suitable for use with RMC or IMC. Provide conduit reducers or EMT to RMC/IMC couplings where required. Combination expansion/deflection couplings shall provide a flexible, watertight connection, accommodating axial or parallel movement of up to 3/4 inch and angular movement of up to 30 degrees from normal and be able to accommodate a maximum of 4 inches of movement in either direction. Combination expansion/deflection couplings shall be suitable and UL listed for use in wet locations.

2.3 OUTLET BOXES, PULL BOXES AND JUNCTION BOXES

UL 514A and ANSI/NEMA OS 1, cadmium- or zinc-coated, if ferrous metal. UL 514C and ANSI/NEMA OS 2, if nonmetallic. Furnish all pull and junction boxes with screw-fastened covers.

2.3.1 Outlet Boxes for Telecommunications System

Provide the following:

- a. Standard type 4 11/16 inches square by 2 1/8 inches deep.
- b. Outlet boxes for wall-mounted telephone outlets: 4 by 2 1/4 by 2 1/8 inches deep. All other telecommunications outlet boxes shall be standard type (or larger).
- c. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.
- d. Outlet boxes for fiber optic telecommunication outlets: include a

minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum one inch conduit system.

2.4 FLOOR OUTLET BOXES

Floor outlet boxes shall be adjustable and concrete tight. Number of gangs and knockout sizes provided shall be as indicated on the drawings. Floor outlet boxes shall accept standard size wall plates.

Provide the following types of floor outlet boxes:

- a. Combination Power and Telecommunications Floor Outlet Boxes

2.5 CABLE TRAYS

NEMA VE 2. Provide the following:

- a. Cable trays: form a wireway system, with a nominal depth as indicated.
- b. Cable trays: constructed of aluminum or steel that has been hot-dipped galvanized after fabrication.
- c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.
- d. Edges, fittings, and hardware: finished free from burrs and sharp edges.
- e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.
- f. Radius of bends: as indicated.
- g. Supports:

Provide support for cable trays at intervals of no more than 6-foot. Place supports for horizontal-elbow tray fittings within 2-feet of each fitting extremity and as recommended by the cable tray manufacturer. Permit both vertical and horizontal adjustment, where possible on supports and hangers. Provide an adequate bearing surface for the tray on the horizontal and vertical tray supports, and ensure that the surface can accommodate holddown clamps or fasteners. Provide a means, other than friction, for securely fastening cable trays to supports.

Ensure that the cable trays can carry at least 150 pounds per linear foot when supported at 6-foot intervals. Ensure that the tray fittings have a load-carrying capacity that is equal to or greater than that of straight tray sections. Ensure that the radius of tray fittings is based on the minimum bending radius of the cables, as specified by the cable manufacturer.

2.5.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 2 by 4 inch. Provide basket cable trays consisting of straight sections of continuous wire mesh, field formed horizontal and vertical bends, tees, drop outs, supports, and accessories.

2.5.2 Ladder-Type Cable Trays

Provide size as indicated. Provide cable runway consisting of side stringers and welded cross members, bends, tees, drop outs, supports, and accessories.

2.6 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet or damp environments, NEMA Type 3R.

2.7 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 24 months prior to date of delivery to site.

2.7.1 Conductors

Provide the following:

- a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.
- b. Conductors No. 8 AWG and larger diameter: stranded.
- c. Conductors No. 10 AWG and smaller diameter: solid.
- d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.
- e. All conductors shall be copper.

2.7.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

- a. Branch circuits: No. 12 AWG.
- b. Class 1 remote-control and signal circuits: No. 14 AWG.
- c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.
- d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.
- e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: Category 5 UTP cables in accordance with DLVLC system manufacturer requirements.

2.7.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.7.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

- a. Grounding conductors: Green.
- b. Neutral conductors: White.
- c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.7.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

- a. 208/120 volt, three-phase
 - (1) Phase A - black
 - (2) Phase B - red
 - (3) Phase C - blue
- b. 480/277 volt, three-phase
 - (1) Phase A - brown
 - (2) Phase B - orange
 - (3) Phase C - yellow

2.7.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where equipment or devices require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.7.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.7.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with size as indicated.

2.7.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications primary bonding busbar (PBB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor as indicated.

2.7.5 Service Entrance Cables

Service Entrance (SE) and Service Entrance (USE) Cables, [UL 854](#).

2.8 SPLICES AND TERMINATION COMPONENTS

[UL 486A-486B](#) for wire connectors and [UL 510](#) for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with [UL 486A-486B](#) or [UL 486C](#) (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.9 DEVICE PLATES

Provide the following:

- a. UL listed, one-piece device plates for outlets to suit the devices installed.
- b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.
- c. For nonmetallic boxes and fittings, other suitable plates may be provided.
- d. Plates on finished walls: nylon or lexan, minimum [0.03 inch](#) wall thickness and same color as receptacle or toggle switch with which they are mounted.
- e. Plates on [unfinished](#) walls: satin finish stainless steel or brushed-finish aluminum, minimum [0.03 inch](#) thick.
- f. Screws: machine-type with countersunk heads in color to match finish of plate.
- g. Sectional type device plates are not be permitted.
- h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.10 SWITCHES

2.10.1 Toggle Switches

[NEMA WD 1](#), [UL 20](#), [commercial grade toggle switches](#) totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

- a. Handles: thermoplastic. [Color shall comply with Division 09 series color schedule](#).
- b. Wiring terminals: screw-type, side-wired.
- c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.
- d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.10.2 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA enclosures as indicated per **NEMA ICS 6.** Disconnect switches in the drying tower shall be rated for 140 degree F.

2.10.3 Elevator Control Disconnect Switches

UL 98. Elevator Control Disconnect Switches shall be designed for elevator application to interrupt the incoming AC power upon receiving a signal from the Fire Alarm Control Panel (FACP). 200kA assembly short-circuit current rating.

2.11 RECEPTACLES

Provide the following:

- a. **UL 498**, general purpose specification grade, grounding-type. Residential grade receptacles are not acceptable.
- b. Ratings and configurations: as indicated.
- c. Bodies: as per **NEMA WD 1.** Color shall comply with Division 09 series Color Schedule.
- d. Face and body: thermoplastic supported on a metal mounting strap.
- e. Dimensional requirements: per **NEMA WD 6.**
- f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.
- g. Grounding pole connected to mounting strap.
- h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.
- i. Controlled receptacles: as required per ASHRAE 90.1. Provide marking for controlled receptacle per **NFPA 70.**

2.11.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.11.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations" with integral GFCI protection. Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, die-cast metal/aluminum extra-duty rated hood.

2.11.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of **UL 943** for Class

A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.11.4 Special Purpose Receptacles

Provide in ratings indicated. Furnish one matching plug with each receptacle.

2.11.5 Plugs

Provide heavy-duty, rubber-covered cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.11.6 Range Receptacles

NEMA 14-50 configuration, flush mounted, rated 50 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.11.7 Dryer Receptacles

NEMA 14-30 configuration, rated 30 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.11.8 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.11.9 Arc-Fault Circuit Interrupter Receptacles

UL 1699, duplex type for mounting in standard outlet box. Provide device capable of detecting series arcing current when the current to ground is 5 amperes or higher, and tripping per requirements of UL 1699.

2.12 RETRACTABLE POWER CORD REEL

Provide heavy duty, all steel construction, NEMA 2 retractable cord reel with powder coat finish. Provide adjustable ratchet that can be engaged (positive lock) or disengaged (constant tension). Provide with ratings and cord reel length as indicated. Provide receptacle at end of cord reel with ratings as indicated.

2.13 PANELBOARDS

Provide panelboards in accordance with the following:

- a. UL 67 and UL 50 having a short-circuit current rating as indicated.
- b. Panelboards for use as service disconnecting means: additionally conform to UL 869A.
- c. Panelboards: circuit breaker-equipped.
- d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

- e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the design drawings. If it is not possible to match "specific breaker placement" during construction, obtain Government approval prior to device installation.
- f. Use of "Subfeed Breakers" is not acceptable.
- g. Main breaker: "separately" mounted "above" or "below" branch breakers.
- h. Where "space only" is indicated, make provisions for future installation of breakers.
- i. Directories: indicate load served by each circuit in panelboard.
- j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).
- k. Type directories and mount in holder behind transparent protective covering.
- l. Panelboards: listed and labeled for their intended use.
- m. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.13.1 Enclosure

Provide panelboard enclosure in accordance with the following:

- a. **UL 50.**
- b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication.
- c. Cabinets: painted in accordance with paragraph FIELD APPLIED PAINTING.
- d. Outdoor cabinets: NEMA 3R raintight with a removable steel plate **1/4 inch** thick in the bottom for field drilling for conduit connections.
- e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.
- f. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than **1/8 inch**.
- g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a **1/2 inch** clear space between the back of the cabinet and the wall surface.
- h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.
- i. Each door: fitted with a combined catch and lock latch.
- j. Keys: two provided with each lock, with all locks keyed alike.

- k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.13.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per [UL 67](#) for connecting grounding conductors; bond to steel cabinet.

2.13.3 Circuit Breakers

[UL 489](#), thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.13.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.13.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

[UL 943](#) and [NFPA 70](#). Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of [UL 943](#) for Class A ground-fault circuit interrupter devices.

2.13.3.3 Arc-Fault Circuit Interrupters

[UL 489](#), [UL 1699](#) and [NFPA 70](#). Molded case circuit breakers: rated as indicated. Provide with "push-to-test" button.

2.14 ENCLOSED CIRCUIT BREAKERS

[UL 489](#). Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated.

2.15 TRANSFORMERS

Provide transformers in accordance with the following:

- a. [NEMA ST 20](#), general purpose, dry-type, self-cooled, ventilated.
- b. Provide transformers in NEMA 1 enclosure.
- c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and four 2.5 percent taps Full Capacity

Below Nominal (FCBN).

d. Transformer insulation system:

- (1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.
- (2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.

e. Transformer of 150 degrees C temperature rise is not acceptable.

f. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

2.15.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in 10 CFR 431, Subpart K.

2.16 MOTORS

Provide motors in accordance with the following:

- a. NEMA MG 1 except provide fire pump motors as specified in Section 21 30 00 FIRE PUMPS.
- b. Hermetic-type sealed motor compressors: Also comply with UL 984.
- c. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.
- d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.
- e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.
- f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.
- g. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.
- h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.
- i. Use Inverter-Rated motors designed to operate with adjustable speed drive (ASD).

2.16.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.16.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated. Electronically Commutated Motors (ECM) to have an integrated controller that senses rotor position and electronically commutates the stator windings to provide synchronous rotation. The rotor must be of a permanent magnet type supported by ball bearings to increase motor efficiency and longevity. The motor must maintain 70 percent or greater efficiency for its design application. ECM motors to comply with UL 1004-1.

2.16.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.16.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment using adjustable speed drive (ASD) manufacturer required wiring type and length as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.17 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

- a. UL 508, NEMA ICS 1, and NEMA ICS 2, except fire pump controllers as specified in Section 21 30 00 FIRE PUMPS.
- b. Provide controllers with thermal overload protection in each phase, and one spare normally open auxiliary contact, and one spare normally

closed auxiliary contact.

- c. Provide controllers for motors rated 1-hp 746 watts and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.
- d. Provide protection for motors from immediate restart by a time adjustable restart relay.
- e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.
- f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.
- g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.
- h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.
- i. Provide selector switch with the means for locking in any position.
- j. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.
- k. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.
- l. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.
- m. Minimum short circuit withstand rating of combination motor controller shall equal that of its upstream panelboard.

2.17.1 Control Wiring

Provide control wiring in accordance with the following:

- a. All control wire: stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.
- b. Hinge wire: Class K stranding.
- c. Current transformer secondary leads: not smaller than No. 10 AWG.

- d. Control wire minimum size: No. 14 AWG.
- e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.
- f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.17.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

- a. NEMA ICS 4.
- b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.
- c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.
- d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.
- e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.
- f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.
- g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.17.2.1 Types of Terminal Blocks

- a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.
- b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.17.3 Control Circuits

Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to [UL 506](#), as applicable. Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. Provide one fused secondary lead with the other lead grounded.

2.17.4 Enclosures for Motor Controllers

[NEMA ICS 6](#).

2.17.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: include compelling relays and multiple-button, station-type with pilot lights for each speed.

2.17.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: heavy duty, oil-tight design.

2.17.7 Pilot and Indicating Lights

Provide LED cluster lamps. Provide transformer, resistor, or diode type.

2.18 [MANUAL MOTOR STARTERS](#) (MOTOR RATED SWITCHES)

[Designed](#) for surface mounting with overload protection and pilot lights.

2.18.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: in accordance with [NEMA ICS 2](#).

2.19 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with [29 CFR 1910.147](#), [NFPA 70E](#) and [29 CFR 1910.303](#). Comply with requirements of Division 23, "Heating, Ventilating, and Air Conditioning (HVAC)" for mechanical isolation of machines and other equipment.

2.20 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires, cable trays, and other accessories for telecommunications outlets and pathway in accordance with [TIA-569](#) and as specified herein. Additional telecommunications requirements are specified in Section [27 10 00](#) BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.21 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

Additional CATV requirements are specified in Section 27 05 13.43 TELEVISION DISTRIBUTION SYSTEM.

2.22 GROUNDING AND BONDING EQUIPMENT

2.22.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional type rods may be used for rods 20 feet or longer.

2.22.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.22.3 Grounding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor installation in accordance with TIA-607. Busbars: plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility and a Secondary bonding busbar (SBB) in all other telecommunications rooms and equipment rooms. The Primary bonding busbar (PBB) and the Secondary bonding busbar (SBB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide bonding busbars with the following:

- a. Predrilled copper busbar provided with holes for use with standard sized lugs,
- b. Minimum dimensions of 0.25 in thick by 4 in wide for the PBB and 2 in wide for SBBs with length as indicated;
- c. Listed by a nationally recognized testing laboratory.

2.23 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.24 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

- a. ASTM D709.
- b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.
- c. Each nameplate inscription: identify the function and, when applicable, the position.

- d. Nameplates: melamine plastic, 0.125 inch thick, white with black center core.
- e. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.
- f. Minimum size of nameplates: one by 2.5 inches.
- g. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.25 WARNING SIGNS

Provide warning signs in accordance with Section 26 05 73 POWER SYSTEM STUDIES.

2.26 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.27 METERING

ANSI C12.1. Provide meters where indicated. Meters shall measure, log, digitally display, and transmit Phase Voltage (V), Current (A), Real Power (W), Reactive Power (VAR), Apparent Power (VA), Power Factor (PF), and Frequency (HZ). The meters shall have user-selectable data logging intervals of 5, 10, 15, 30, 60 minutes, or 1 day. The meters shall transmit data at least daily. The meters shall comply with ANSI C12.1. See Division 23 control system specifications for communication protocol type. The electrical contractor shall coordinate the meter communication protocol and conductor types with the control contractor prior to ordering.

2.28 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance and indicated panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Do not install SPD inside a panelboard or switchboard enclosure. However, SPD may be installed in a separate compartment of a switchgear provided that it is supplied by a dedicated circuit breaker. SPD must have the same short-circuit current rating as the protected equipment and must not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
Neutral to ground (N-G)
Phase to ground (L-G)

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes

(L-N, L-G, and N-G) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G).

Provide SPDs.

Maximum L-N, and N-G Voltage Protection Rating:

700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:

700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system
1,800V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120 percent of nominal voltage for 240 volts and below; 115 percent of nominal voltage above 240 volts to 480 volts.

2.29 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

- a. **NEMA 250** corrosion-resistance test and the additional requirements as specified herein.
- b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.
- c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.
- d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.
- e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.
- f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.
- g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.30 SOURCE QUALITY CONTROL

2.30.1 Transformer Factory Tests

Submittal: include routine **NEMA ST 20** transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal

to those specified.

2.31 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 05 73 POWER SYSTEM STUDIES.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings or under floor slabs and where conduit will be visible after completion of project.

3.1.4.1 Restrictions Applicable to EMT

- a. Do not install underground.
- b. Do not encase in concrete, mortar, grout, or other cementitious materials.
- c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.
- d. Do not use in hazardous areas.
- e. Do not use outdoors.
- f. Do not use in fire pump rooms.
- g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to Nonmetallic Conduit

- a. PVC Schedule 40.
 - (1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.
 - (2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.
- b. PVC Schedule 80.
 - (1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.
 - (2) Do not use in hazardous (classified) areas.
 - (3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

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3.1.4.3 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.4 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40
Plastic coating: extend minimum 6 inches above floor.

3.1.4.5 Conduit Installed Under Floor Slabs

Do not install conduits underneath the drying tower floor slab.

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier. Use NECA NEIS 1 Table 2a (Minimum Raceway Spacing) to determine under floor slab conduit spacing unless greater spacing is required elsewhere in this section.

3.1.4.6 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

3.1.4.7 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.8 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Plastic cable ties are not acceptable. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Identify independent conduit support in both fire and non-fire rated assemblies per NFPA 70. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Where conduit crosses building expansion joints, provide suitable expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the

equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.9 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.10 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by [NFPA 70](#), where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by [NFPA 70](#).

3.1.4.11 Flexible Connections

Provide flexible steel conduit between [3 and 6 feet](#) in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: [1/2 inch](#) diameter. Provide liquid tight flexible nonmetallic conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections. Plastic cable ties are not acceptable as a support method.

3.1.4.12 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with [TIA-569](#).

- a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with [TIA-568.1](#). Size conduits and cable trays in accordance with [TIA-569](#) and as indicated.
- b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): installed in accordance with [TIA-569](#). Size conduits and cable trays for telecommunications risers in accordance with [TIA-569](#) and as indicated.

3.1.4.13 Community Antenna Television (CATV) System Conduits

Install a system of CATV wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires, cable trays, and other accessories for CATV outlets and pathway in accordance with [TIA-569](#).

3.1.5 Cable Tray Installation

Install and ground in accordance with [NFPA 70](#). In addition, install and ground telecommunications cable tray in accordance with [TIA-569](#), and [TIA-607](#). Install cable trays parallel with or at right angles to

ceilings, walls, and structural members. Cable tray and tray supports must not partially nor completely obstruct access to the room. Support in accordance with NEMA VE 2 and with manufacturer recommendations but at not more than 6 foot intervals. Coat contact surfaces of aluminum connections with an antioxidant compound prior to assembly. Adjacent cable tray sections: bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00, FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Provide pullboxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than 100 feet or with more than three right-angle bends, install a pullbox at a convenient intermediate location. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations: sheet steel, and nonmetallic boxes may be used with nonmetallic conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.6.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet.

3.1.6.1.1 Wall-Mounted Telecommunications Outlet Box

Provide double gang electrical boxes, minimum standard size 4-11/16 inches square and 2-1/8 inches deep with plaster ring for connection of single gang faceplate. Design outlet box for recess mounting with the faceplate flush with the wall surface, at the same height as the electrical outlets.

3.1.6.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, and compatible with nonmetallic raceway systems, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.7 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of center of grip of the operating handle of the switch or circuit breaker at its highest position is maximum 79 inches above floor or working platform or as allowed in Section 404.8 per NFPA 70. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets: mounted at height 60 inches above finished floor. Measure mounting heights of wiring devices and outlets to center of device or outlet.

3.1.8 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and manufacturer's recommendations. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.8.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

- a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.
- b. Use permanent ink for the wire numbers
- c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.
- d. Size marking strips to accommodate the two sets of wire numbers.
- e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to

which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

- f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.
- g. Prints of the [marking strips](#) drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.9 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.10 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of [1/16 inch](#). Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.11 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section [07 84 00](#) FIRESTOPPING.

3.1.12 Grounding and Bonding

Provide in accordance with [NFPA 70](#) and [NFPA 780](#). Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems.

Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with [NFPA 70](#).

Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system.

In addition to the requirements specified herein, provide telecommunications grounding in accordance with [TIA-607](#). Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.12.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in [IEEE 81](#). If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.12.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or high compression connector.

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.
- b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.12.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately [4 inches](#) above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment.

3.1.12.4 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.12.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

- a. Telecommunications Grounding Busbars: Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility. Install the PBB as close to the electrical service entrance grounding connection as practicable. Provide a Secondary bonding busbar (SBB) in all other telecommunications rooms and telecommunications equipment rooms. Install the SBB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the SBB near the backbone cabling and associated terminations. In

addition, locate the SBB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a SBB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the SBB. Install Secondary bonding busbars to maintain clearances as required by NFPA 70 and insulated from its support. A minimum of 2 inches separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.

- b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the PBB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum. Provide a telecommunications bonding backbone (TBB) that originates at the PBB extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a SBB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the PBB or the SBB.
- c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB or SBB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the PBB or SBB to the PBB or SBB respectively. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB and SBB to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the SBB or PBB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the SBB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.13 Equipment Connections

Provide power wiring for the connection of motors and control equipment

under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.14 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at midheight of elevator shaft, and work light and outlet receptacle in elevator pit.

3.1.15 Watthour Meters

ANSI C12.1.

3.1.16 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends. Do not locate surge protective devices inside a panelboard or switchboard enclosure.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets. Provide nameplate on all equipment in access controlled spaces and areas.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Where field painting of enclosures for panelboards or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test. Where applicable, test electrical equipment in accordance with NETA ATS.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per [NETA ATS](#) to provide direct reading of resistance. All existing wiring to be reused must also be tested.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in [NETA ATS](#). Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in [UL 943](#).

3.5.5 Arc-Fault Receptacle Test

Test arc-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in [UL 1699](#).

3.5.6 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.7 Watthour Meter

a. Visual and mechanical inspection

- (1) Examine for broken parts, shipping damage, and tightness of connections.
- (2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

- (1) Determine accuracy of meter.
- (2) Calibrate watthour meters to one-half percent.
- (3) Verify that correct multiplier has been placed on face of meter,

where applicable.

3.5.8 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

-- End of Section --

SECTION 26 24 13

SWITCHBOARDS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP (2019) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A653/A653M (2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A780/A780M (2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM D149 (2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

ASTM D1535 (2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE C2 (2023) National Electrical Safety Code

IEEE C37.90.1 (2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE C57.12.28 (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1 (2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less

NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures

NEMA PB 2 (2011) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 489 (2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 891 (2019) UL Standard for Safety Switchboards

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard Drawings; G, D0

SD-03 Product Data

Switchboard; G, D0

SD-06 Test Reports

Switchboard Design Tests; G, R0

Switchboard Production Tests; G, R0

Acceptance Check and Test Reports; G, R0

SD-07 Certificates

Qualifications; G, R0

Acceptance Check and Test Procedures; G, R0

SD-10 Operation and Maintenance Data

Switchboard Operation and Maintenance, Data Package 5; G, R0

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G, R0

Equipment Test Schedule; G, R0

Required Settings; G, D0

Service Entrance Available Fault Current Label; G, R0

1.4 QUALITY ASSURANCE

1.4.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchboard including:

- a. Circuit breaker type, interrupting rating, and trip devices, including available settings.
- b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.4.2 Switchboard Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military,

industry, and technical society publication references on submittals.
Include the following:

- a. One-line diagram including breakers and meters.
- b. Outline drawings including front elevation, section views, footprint, and overall dimensions.
- c. Bus configuration including dimensions and ampere ratings of bus bars.
- d. Markings and NEMA nameplate data.
- e. Circuit breaker type, interrupting rating, and trip devices, including available settings.
- f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.
- g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. This information shall be used to provide breaker settings that ensures protection and coordination are achieved as part of SECTION 26 05 73 POWER SYSTEM STUDIES.

1.4.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests,

is furnished.

1.4.4.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to site are not acceptable.

1.4.5 Testing Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

- a. Submit name and qualifications of organization. Organization shall have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization shall have a calibration program, and test instruments used shall be calibrated in accordance with NETA ATS.
- b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments shall be performed by an engineering technician, certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.5 MAINTENANCE

1.5.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

- a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.
- b. Catalog data required by the paragraph SD-03, PRODUCT DATA.
- c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.
- d. Prices for spare parts and supply list.
- e. Information on metering.
- f. Design test reports.

- g. Production test reports.

1.6 WARRANTY

Provide equipment items that are supported by service organizations reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchboards and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Required settings shall be obtained from the coordinated power system protection study specified in SECTION 26 05 73 POWER SYSTEM STUDIE.

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

Provide equipment with the following ratings:

- a. Voltage rating: 480Y/277 volts AC, three-phase, 4-wire.
- b. Continuous current rating of the main bus: as indicated.
- c. Short-circuit current rating: as indicated.
- d. UL listed and labeled as service entrance equipment.

2.2.2 Construction

Provide the following:

- a. Switchboard: consisting of one or more vertical sections bolted together to form a rigid assembly and front and rear aligned.
- b. All circuit breakers: front accessible.
- e. Where indicated, "space for future" or "space" means to include a vertical bus provided behind a blank front cover. Where indicated, "provision for future" means full hardware provided to mount a breaker suitable for the location.
- f. Completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

Provide the following:

- a. Enclosure: NEMA ICS 6 Type 1.

- b. Enclosure: bolted together with removable bolt-on side and rear covers.
- c. Front doors: provided with vault handles with a three point catch.
- d. Bases, frames and channels of enclosure: corrosion resistant and fabricated of galvanized steel.
- e. Base: includes any part of enclosure that is within 3 inches of concrete pad.
- f. Galvanized steel: ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.
- g. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.
- h. Paint coating system: comply with IEEE C57.12.28 for galvanized steel.

2.2.2.2 Bus Bars

Provide the following:

- a. Bus bars: copper with silver-plated contact surfaces
 - (1) Phase bus bars: insulated with a tape wrap or insulating sleeve providing a minimum breakdown voltage of 16,000 volts per ASTM D149.
 - (2) Neutral bus: rated 100 percent of the main bus continuous current rating as indicated.
- b. Make bus connections and joints with hardened steel bolts.
- c. Main-bus (through bus): rated at the full ampacity of the main throughout the switchboard.
- d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard.

2.2.2.3 Main Section

Provide the main section consisting of an individually mounted fixed molded-case circuit breaker, meter, and ground fault protection device.

2.2.2.4 Distribution Sections

Provide the distribution section(s) consisting of group mounted, molded-case circuit breakers as indicated.

2.2.2.5 Handles

Provide handles for individually mounted devices of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Molded-Case Circuit Breaker

Provide the following:

- a. **UL 489.** UL listed and labeled, manually operated, low voltage molded-case circuit breaker, with a short-circuit current rating **as indicated.**
- b. Breaker frame size: as indicated.
- c. Series rated circuit breakers are unacceptable.

2.2.4 Electronic Trip Units

Equip main breaker with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

- a. Current sensors ampere rating: as indicated.
- b. Trip unit ampere rating: as indicated.
- c. Ground fault protection.
- d. Electronic trip units: provide additional features as indicated:
 - (1) **Main** Breaker: include long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.
 - (2) Main breaker: include short delay pick-up and time settings and, instantaneous settings and ground fault settings.
 - (3) Distribution breakers **250A and larger:** include short delay pick-up and time settings, instantaneous settings.
 - (4) Main Breaker: include a digital display for phase and ground current.
 - (5) Main Breaker: include a digital display for watts, vars, VA, kWh, kvarh, and kVAh.
 - (6) Main Breaker: include a digital display for phase voltage, and percent THD voltage and current.
 - (7) Main Breaker: include provisions for communication via a network twisted pair cable for remote monitoring and control. Provide the communications protocol **as specified in Division 25.**
 - (8) For electronic trip units that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator.

2.2.5 Metering

2.2.5.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in a sealed case with the following features.

a. Display capability:

- (1) Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.
- (2) Power Meter: Display Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power.
- (3) Volt Meter: Provide capability to be selectable between display of the three phases of phase to neutral voltages and display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, over percent THD.
- (4) Ammeter: Display phase A, B, and C currents. Detected alarm conditions include over/under current, over percent THD.
- (5) Digital Watthour Meter: Provide a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). Include a Form C KYZ pulse output relay on the meter.

- b. Provide programming via a front panel display and a communication interface accessible by a computer.
- c. Provide password secured programming stored in non-volatile EEPROM memory.
- e. Provide the communications protocol as specified in Division 25.
- f. Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.
- g. Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.
- h. Provide meter with a display of Total Harmonic Distortion (THD) measurement to a minimum of the thirty-first order.

2.2.5.2 Submetering

ASHRAE 90.1 - IP. Provide submetering where indicated.

2.2.6 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.7 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, **0.125 inch** thick, white with black center core. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of **one by 2.5 inches**. Provide lettering that is a minimum of **0.25 inch** high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Provide the following as part of test equipment calibration:

- a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

- b. Accuracy: Traceable to the National Institute of Standards and Technology.
- c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.
- d. Dated calibration labels: visible on all test equipment.
- e. Calibrating standard: higher accuracy than that of the instrument tested.
- f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:
 - (1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.
 - (2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and UL 891.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

- a. Short-circuit current test.
- b. Enclosure tests.
- c. Dielectric test.

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

- a. 60-hertz dielectric tests.
- b. Mechanical operation tests.
- c. Electrical operation and control wiring tests.
- d. Ground fault sensing equipment test.

2.6 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 05 73 POWER SYSTEM STUDIES.

2.7 ARC FLASH WARNING LABEL

Provide warning label for switchboards as specified in Section 26 05 73 POWER SYSTEM STUDIES. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.8 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchboards used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation. Locate this self-adhesive warning label on the outside of the switchboard. Provide label format as indicated.

2.9 MIMIC BUS LABELING

Provide a mimic bus on the front of the equipment to diagrammatically show the internal bus structure of the lineup.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 41 00 LIGHTNING PROTECTION SYSTEM..

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

ANSI/NEMA PB 2.1.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been

applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Interior Location

Mount switchboard on concrete slab as follows:

- a. Unless otherwise indicated, provide the slab with dimensions at least **4 inches** thick.
- b. Install slab such that the top of the concrete slab is approximately **4 inches** above the finished grade.
- c. Provide edges above grade **1/2 inch** chamfer.
- d. Provide slab of adequate size to project at least **8 inches** beyond the equipment.
- e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.
- f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.
- g. Cut off and bush conduits **3 inches** above slab surface.
- h. Provide concrete work as specified in Section **03 30 00** CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Ensure Required Settings of breakers are submitted as part of the coordinated power system protection study specified in SECTION 26 05 73 POWER SYSTEM STUDIES to the Contracting Officer after approval of switchboard and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with **NETA ATS**.

Submit a report for Acceptance Check and Test Procedures at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

Submit certified copies of Acceptance Check and Test Reports. Reports shall include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical, electrical, and mechanical condition.
- (3) Verify appropriate anchorage, required area clearances, and correct alignment.
- (4) Clean switchboard and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
- (5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
- (6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker's address for microprocessor-communication packages.
- (7) Verify that current transformer ratios correspond to approved shop drawings.
- (8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
- (9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
- (10) Confirm correct application of manufacturer's recommended lubricants.
- (11) Inspect insulators for evidence of physical damage or contaminated surfaces.
- (12) Verify correct barrier installation.
- (13) Exercise all active components.
- (14) Inspect all mechanical indicating devices for correct operation.
- (15) Verify that filters are in place and vents are clear.
- (16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.
- (17) Inspect control power transformers.

b. Electrical Tests

- (1) Perform insulation-resistance tests on each bus section.
- (2) Perform dielectric withstand voltage tests.

- (3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.
- (4) Perform control wiring performance test.
- (5) Perform primary current injection tests on the entire current circuit in each section of assembly.

3.5.1.2 Circuit Breakers

Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

- (1) Compare nameplate data with specifications and approved shop drawings.
- (2) Inspect circuit breaker for correct mounting.
- (3) Operate circuit breaker to ensure smooth operation.
- (4) Inspect case for cracks or other defects.
- (5) Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.
- (6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

- (1) Perform contact-resistance tests.
- (2) Perform insulation-resistance tests.
- (3) Perform Breaker adjustments for final settings in accordance with Government provided settings.
- (4) Perform long-time delay time-current characteristic tests
- (5) Determine short-time pickup and delay by primary current injection.
- (6) Determine ground-fault pickup and time delay by primary current injection.
- (7) Determine instantaneous pickup current by primary injection.
- (8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.

- (2) Inspect physical and mechanical condition.
- (3) Verify correct connection.
- (4) Verify that adequate clearances exist between primary and secondary circuit.
- (5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
- (6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

- (1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
- (2) Perform insulation-resistance tests.
- (3) Perform polarity tests.
- (4) Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify tightness of electrical connections.

b. Electrical Tests

- (1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.
- (2) Calibrate watt-hour meters according to manufacturer's published data.
- (3) Verify all instrument multipliers.
- (4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

- (1) Inspect ground system for compliance with contract plans and specifications.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer five working days advance notice of the dates and times for checks, settings, and tests.

3.6 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

-- End of Section --

SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS

PART 1 GENERAL

1.1 REFERENCES

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

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3 (2017) Requirements for the Control of
Electromagnetic Interference
Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519 (2014) Recommended Practices and
Requirements for Harmonic Control in
Electrical Power Systems

IEEE C62.41.1 (2002; R 2008) Guide on the Surges
Environment in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on
Characterization of Surges in Low-Voltage
(1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

NEMA ICS 1 (2022) Standard for Industrial Control and
Systems: General Requirements

NEMA ICS 3.1 (2019) Guide for the Application,
Handling, Storage, Installation and
Maintenance of Medium-Voltage AC
Contactors, Controllers and Control Centers

NEMA ICS 6 (1993; R 2016) Industrial Control and
Systems: Enclosures

NEMA ICS 7 (2014) Adjustable-Speed Drives

NEMA ICS 7.2 (2015) Application Guide for AC Adjustable
Speed Drive Systems

NEMA MG 1 (2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National

Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15

Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489

(2016; Rev 2019) UL Standard for Safety
Molded-Case Circuit Breakers, Molded-Case
Switches and Circuit-Breaker Enclosures

UL 61800-5-1

(2021) UL Standard for Safety Adjustable
Speed Electrical Power Drive Systems -
Part 5-1: Safety Requirements -
Electrical, Thermal and Energy

UL 61800-5-2

(2021) UL Standard for Safety Adjustable
Speed Electrical Power Drive Systems -
Part 5-2: Safety Requirements - Functional

1.2 SYSTEM DESCRIPTION

1.2.1 Performance Requirements

1.2.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.2.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.2.2 Electrical Requirements

1.2.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.2.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

- a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
- b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Test Plan; G, R0

SD-02 Shop Drawings

Schematic Diagrams; G, R0
Interconnecting Diagrams; G, R0
Installation Drawings; G, R0
As-Built Drawings; G, R0

SD-03 Product Data

Adjustable Speed Drives; G, R0
Wires and Cables; G, R0
Equipment Schedule; G, R0

SD-06 Test Reports

ASD Test; G, R0
Performance Verification Tests; G, R0
Endurance Test; G, R0

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Report; G, R0

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.4 QUALITY ASSURANCE

1.4.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.4.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external

interfaces, including power and signal conductors. Include for enclosures and external devices.

1.4.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for government approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the [as-built drawings](#).

1.4.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.4.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.4.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year. Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Government. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.7 MAINTENANCE

1.7.1 Spare Parts

Provide two spare fuses for each piece of equipment.

Additionally, manufacturers shall provide spare parts list for each piece of equipment.

1.7.2 Operation and Maintenance Data

Provide in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.7.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.7.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

- a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.
- b. A converter stage per UL 61800-5-1 and UL 61800-5-2 must change fixed

voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

- c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.
- d. The ASD shall be capable of supplying 120 percent of rated full load current for one minute at maximum ambient temperature.
- e. The ASD must be designed to operate from the voltage and phase indicated, plus or minus 10 percent, 60 Hz supply, and control motors with a corresponding voltage rating.
- f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

- g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.
- h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.
- i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.
- j. The controller efficiency at any speed must not be less than 96 percent.
- k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.
- l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:
 - (1) Short circuit at controller output
 - (2) Ground fault at controller output

- (3) Open circuit at controller output
- (4) Input undervoltage
- (5) Input overvoltage
- (6) Loss of input phase
- (7) AC line switching transients
- (8) Instantaneous overload
- (9) Sustained overload exceeding 115 percent of controller rated current
- (10) Over temperature
- (11) Phase reversal
- m. Solid state motor overload protection must be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.
- n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.
- o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.
- p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.
- q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The ASD must have a minimum of three user selectable bandwidths.
- r. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.
- s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter

assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

- (1) The Voltage THD should not exceed 2.0 percent THD.
- (2) The Current THD should not exceed 15.0 percent THD.
- (3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.
- (4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

2.1.1.1 ASD for HVAC Application

ASDs must have the following features:

- a. A local operator control providing the following functions:
 - (1) Remote/Local operator selection with password access.
 - (2) Run/Stop and manual speed commands.
 - (3) All programming functions.
 - (4) Scrolling through all display functions.
- b. A local operator control panel with the following data displayed:
 - (1) ASD status.
 - (2) Frequency.
 - (3) Motor RPM.
 - (4) Phase current.
 - (5) Scrolling through all display functions.
 - (6) Fault diagnostics in descriptive text.
 - (7) All programmed parameters.
- c. Standard PI loop controller with input terminal for controlled variable and parameter settings.
- d. User interface terminals for remote control of ASD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.
- e. An isolated form C SPDT auxiliary relay which energizes on a run command.

- f. An adjustable carrier frequency with 16 KHz minimum upper limit.
- g. A built-in or external line reactor with 3 percent minimum impedance to protect the DC bus capacitors and rectifier section diodes, reduce power line transient voltage, line notching, DC bus over-voltage tripping and improve the inverter over-current and over-voltage conditions.
- h. Historical logging information and displays:
 - (1) Real-time clock with current time and date.
 - (2) Running log of total power versus time.
 - (3) Total run time.
 - (4) Fault log, maintaining last four faults with time and data stamp for each.
- i. The ASD must be capable of automatic control by a remote control signal, by DDC network command, or manually by the ASD control panel. See Division 23 for DDC communications protocol.
- j. ASDs must include the following operator programmable parameters:
 - (1) Upper and lower limit frequency.
 - (2) Acceleration and deceleration rate.
 - (3) Variable torque volts per Hertz curve.
 - (4) Starting voltage level.
 - (5) Starting frequency level.
 - (6) Display speed scaling.
 - (7) Enable/disable soft stall feature.
 - (8) Motor overload level.
 - (9) Motor stall level.
 - (10) Jump frequency and hysteresis band.
 - (11) PWM carrier frequency.
- k. ASD must have the following protective features:
 - (1) An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.
 - (2) An electronic adjustable soft stall feature, allowing the ASD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload ASD will automatically return to the requested frequency when load conditions permit.

- (3) A separate electronic stall at 110 percent ASD rated current, and a separate hardware trip at 190 percent current.
- (4) The ability to shut down if inadvertently started into a rotating load without damaging the ASD or the motor.
- (5) The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.
- (6) The ability to sustain 110 percent rated current for 60 seconds.
- (7) The ability to shutdown safely or protect against and record the following fault conditions:
 - (a) Over current (and an indication if the over current was during acceleration, deceleration, or running).
 - (b) Over current internal to the drive.
 - (c) Motor overload at start-up.
 - (d) Over voltage from utility power.
 - (e) Motor running overload.
 - (f) Over voltage during deceleration.
 - (g) ASD over heat.
 - (h) Load and ground fault.
 - (h) Abnormal parameters or data in ASD EEPROM.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per **NEMA ICS 3.1**, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per **NEMA ICS 7.2**, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed **test plan** must be submitted to the Government for approval, at least 28 calendar days prior to proposed testing. The tests must conform to **NEMA ICS 1**, **NEMA ICS 7**, and the manufacturer's safety regulations. The Government reserves the right to witness the tests and review the documentation. Do not perform testing until the Government has approved the test plan. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test with the assistance of a factory-authorized service representative.

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is

met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

- a. System overview
- b. General theory of operation
- c. System operation
- d. Alarm formats
- e. Failure recovery procedures
- f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional

operations of the system. This training must include:

- a. System overview
- b. General theory of operation
- c. System operation
- d. System configuration
- e. Alarm formats
- f. Failure recovery procedures
- g. Troubleshooting and repair
- h. Maintenance and calibration
- i. System programming and configuration

-- End of Section --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National Electrical Code

NFPA 780 (2023) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)

DAFMAN 32-1065 (2020) Grounding and Electrical Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-575-01 (2012; with Change 1, 2021) Lightning and Static Electricity Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 96 (2016; May 2023) UL Standard for Safety Lightning Protection Components

UL 96A (2016; Reprint Oct 2022) UL Standard for Safety Installation Requirements for Lightning Protection Systems

UL 1449 (2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices

UL Electrical Construction (2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer after engineering approval and

before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest products of a manufacturer regularly engaged in production of lightning protection system components. Products must be UL listed for use on lightning protection systems unless this rating does not exist for items in question.

Comply with NFPA 70, NFPA 780, UL 96, and UFC 3-575-01.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G, R0

Grounding Systems Testing; G, R0

SD-07 Certificates

Lightning Protection System Installers Documentation; G, R0

Component UL Listed and Labeled; G, R0

Lightning Protection System Inspection Certificate; G, R0

Roof Manufacturer's Warranty; G, R0

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should," wherever it appears. Interpret references that require LPS expertise in these standards to mean Base Civil Engineer (BCE) or BCE-designated representative with LPS training certification.

1.4.1 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled for

use on lightning protection systems. Listing alone in [UL Electrical Construction](#), which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally-recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories (UL).

1.4.2 Lightning Protection and Grounding System Test Plan

Provide lightning protection system and grounding system test plans in compliance with [NFPA 780](#) and [DAFMAN 32-1065](#) chapters 8 and 10, and Attachment 7. Identify (by number or letter, at the preference of the base - 1.2.3. or a.b.c.) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. [DAFMAN 32-1065](#), Attachment 7, contains a Sample Visual Inspection Form (Figure A7.6) and a Sample 24-month Resistance/Continuity Test/Visual Inspection of LPS and Grounding System (Figure A7.7). Substitute-Forms may be used, but those forms created or substituted by the base must include the same contents and information as the samples provided in Attachment 7, Figures A7.6 and A7.7. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements as "Testing of Integral Lightning Protection System" in the test plan. For explosives facilities, the rolling sphere must be superimposed in elevation drawings, on all three of these types of lightning protection systems for installations with a high strike density as indicated in the NOAA Strike Density Maps. This may be accomplished by Computer Aided Design (CAD). Integral systems are discouraged on explosives and communications facilities because it has the potential to bring lightning closer to what is being protected. For explosives facilities, record drawings with materials description (wire size, air terminal material, etc.) is required by the base Weapons Safety Office. Testing of Surge Protective Devices must comply with [UL 1449](#) and annual inspection of Surge Protective Devices should be included on Figures A7.6 and A7.7.

1.4.3 Lightning Protection System Inspection Certificate of Qualifications

Provide an approved third-party inspector who meets training certification requirements for final acceptance of the LPS. Inspection and certification of the LPS must be completed and certified in writing, before occupancy of the building. Compliance requirements are in [UFC 3-575-01](#) and [DAFMAN 32-1065](#), paragraphs 4.2 and 4.3. Signed Certificate of Qualifications must be placed in the LPS records.

Optional certification (also described in [UFC 3-575-01](#) and [DAFMAN 32-1065](#)): If available, base may provide LPS third-party qualified personnel via BCE-designated base individual who 1) routinely maintains and tests the lightning protection system and 2) has had advanced training, with a Certificate or Qualification signed and provided by the trainer, for LPS records. This option removes the requirement for a project-included third-party inspector to certify the LPS prior to LPS system acceptance.

Note that the Contracting Officer may not accept the LPS system without a recommendation from a qualified person identified in the project documents.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in the field, and

advise the Contracting Officer of any discrepancy before starting any work, if known at that time, or when it becomes known while performing work. Obtain prior approval of the BCE or BCE-designated representative with LPS training certification before design changes are made.

PART 2 PRODUCTS

2.1 MATERIALS

See [NFPA 70](#), [NFPA 780](#), [UFC 3-575-01 DAFMAN 32-1065](#). Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of [UL 96](#) classes, as applicable.

2.1.1 Main and Bonding Conductors

Main and Bonding Conductors should be [NFPA 780](#) and [UL 96](#) Class I or Class II materials, as applicable. For explosives, Class II materials are in accordance with [NFPA 780](#), Chapter 8.

2.1.2 Conductors

Provide copper or aluminum conductors, as applicable. See [NFPA 780](#), [UFC 3-575-01 DAFMAN 32-1065](#).

2.2 COMPONENTS

2.2.1 Air Terminals on Integral Systems

Provide solid air terminals. Tubular air terminals are not permitted. Support air terminals more than [24 inches](#) in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods conforming to [NFPA 780](#). Provide ground rods that are not less than [5/8 inch](#) in diameter and [8 feet](#) in length. Do not mix ground rods of copper-clad steel and solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to [UL 96](#), class as applicable. Conductor connections can be made by compression clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that

conform to NFPA 780 and UL 96.

2.2.5 Roofing Contractor Components and Accessories

Roofing Contractor shall provide and install components and accessories (e.g., flashing boots, washers, sealant, etc.) as required by the roofing manufacturer to meet the requirements of the warranty.

PART 3 EXECUTION

3.1 LIGHTNING PROTECTION SYSTEMS

Provide a lightning protection system that meets the requirements of NFPA 780 and UFC 3-575-01.

3.1.1 Integral Lightning Protection System

The integral type lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor for the purpose of carrying lightning current from a direct strike to ground in a manner that will protect assets and personnel. Expose all conductors on the structures except where exterior down conductors are required to be in protective sleeves for prevention of mechanical damage (6 feet above grade level). Integral systems are the least preferred, especially for explosives and communications facilities. When use of integral systems is determined by the designer or site conditions to be necessary, do not run down conductors inside columns or other methods which will prevent visual access for required inspections. Visual access is required by NFPA 780 and DAFMAN 32-1065 so that the annual visual inspection may be performed on all LPS components.

Make interconnections within side-flash distances between down conductors and metallic equipment mounted on the exterior or interior of a facility, at or below the level of the grounded metallic parts. Calculate side-flash distances in accordance with NFPA 780. Be aware of side flashes that may occur through exterior walls.

Note that integral systems should be avoided as LPS for Explosives and Communications facilities and is discouraged for general facilities. Installation and maintenance costs of an integral system are excessive and this method is maintenance intensive. The complexity and number of test points dictates frequent interruption to missions and daily operations for required annual inspections and testing. Integral systems require fall protection and maintenance of that fall protection system. For fall protection, maintain NFPA 780-compliant separation distance between the integral system and metallic fall protection.

3.1.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors. Adhesive fasteners may be used on the roof if the installation is observed by base-qualified personnel to be compliant with manufacturer's instructions. Installation must be observed until the observer is satisfied that the proper methods for preparing the surface are being performed. These fasteners will be added and considered a test point in Base records and must be part of the annual inspection. Observer must date and sign the test record.

No connection or physical attachment is allowed to any coping system on the roof as this violates the integrity and warranty of the coping system.

3.1.1.2 Air Terminals

Use of adhesive fasteners, when installing air terminals on "rubber" (EPDM) type roofs, should be in accordance with adhesive and roof manufactures' recommendations. See paragraph ROOF-MOUNTED COMPONENTS.

3.1.1.3 Roof Conductors

Roof conductors should comply with NFPA 780 and DAFMAN 32-1065.

3.1.2 Down Conductors

A minimum of two paths to ground shall be provided on any system. This may be by two down conductors or with a down conductor in combination with other metallic connections to ground. Protect exposed down conductors from physical damage from ground level up to 6 feet. If this protection is a metal conduit, both ends must be bonded to the down conductor passing through it. For Schedule 80 conduit providing this protection, no bonding at both ends is necessary. Schedule 80 conduit or metallic conduit may be painted to match the surrounding surface. NO CONNECTIONS OR FASTENERS OF ANY LIGHTNING PROTECTION SYSTEM MAY BE PAINTED because this affects the ease with which lightning current can pass to ground.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to a ground rod below grade by exothermic weld for all buried connections and exothermic weld or compression connectors for connections inside test wells. Terminate all down conductors to a grounding electrode inside a test well. Test connections and record resistances and continuity readings prior to covering.

Accessible connections above ground level and in test wells can be grounded with mechanical clamping, meeting installation requirements in NFPA 780.

3.1.4 Installation of Grounding Electrodes (Ground Rods)

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not-less-than 8 feet if exothermic welds are used for bonds. Inside test wells, the 5/8 in. by 8 ft rod may be driven to a point above the base of the test well, that will provide working/testing access to the mechanically-fastened bond. Set ground rods not less than 3 feet nor more than 6 feet (see NFPA 780) from the structural foundation, and at least 3 feet beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a single driven ground rod is 25 ohms (NFPA 780). If resistance-to-ground of a single ground rod for the lightning protection system exceeds 25 ohms and another ground rod is driven in accordance with NFPA 780, 25 ohms does not apply to this test point. See NFPA 70 exception to Article 250.53.

3.2 APPLICATIONS

3.2.1 Personnel Ramps and Covered Passageways

Lightning Protection is required in accordance with NFPA 780 and UFC 3-575-01.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system at the point where the fence, any fence post, or gate is within 6 feet of any part of the lightning protection system (usually a down conductor) in accordance with ANSI C2 and NFPA 780 and UFC 3-575-01.

3.4 RESTORATION

Where sod has been removed, replace sod as soon as possible after completing the backfilling. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work, to original condition. Overfill the trench to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration, to match existing. Maintain disturbed surfaces and replacements until final acceptance. Return to site after six months to fill in compacted surface.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection Systems Testing

A 100 percent test point test and inspection is required by all services. Identify test points for lightning protection system connections and bonds. Provide a sketch (NTS) with identified test points as part of the contract acceptance. Number points in a manner consistent with the installation (Base or Post) nomenclature for existing lightning protection systems; for example, use letters or numbers to track the test results. Test each lightning protection system connection to ensure continuity across each connection or bond is 1 ohm or less, and record the value indicated on a copy of the test form located at the back of DAFMAN 32-1065, Attachment 7.

- a. LPS testing must also be accomplished on smaller projects, such as roofing and HVAC projects, where lightning protection systems are installed on any facility with existing LPS, to ensure the LPS is not damaged or reconfigured during construction.
- b. Comply with UL 96A. A third-party inspector (not the designer and not the installer) must be present for the 100 percent inspection and data documentation by the contractor. This is to take place prior to project acceptance. Note that in many cases Air Force personnel have been trained to inspect and accept projects as the third-party inspector. Verify this before contract award.

3.5.2 Grounding Systems Testing

A 100 percent test point resistance test and inspection is required. Identify all test points for grounding system connections and bonds. Provide a sketch (NTS) with identified test points as part of the contract

acceptance. Number points in a manner consistent with the installation (Base or Post) nomenclature for existing grounding systems; for example, use letters or numbers to track the test results. Test each grounding system connection or bond to ensure resistance-to-ground is 25 ohms or less or as excepted by NFPA 70 or NFPA 780. Record the resistance measurement on a copy of the test form located at the back of DAFMAN 32-1065 for Air Force or a similar form provided by the Army or Navy. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, and not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --

SECTION 26 42 13

GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A194/A194M	(2023) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B418	(2016a; R2021) Standard Specification for Cast and Wrought Galvanic Zinc Anodes
ASTM B843	(2018) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction

NACE INTERNATIONAL (NACE)

NACE SP0177	(2019) Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP21424	(2018) Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation and Monitoring

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 7 2023; TIA 23-15) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-18001	(1993) Anodes, Sacrificial Zinc Alloy
UFC 3-570-06	(2016; with Change 1, 2019) Cathodic Protection

UNDERWRITERS LABORATORIES (UL)

UL 6	(2022) UL Standard for Safety Electrical

Rigid Metal Conduit-Steel

UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings

1.2 DEFINITIONS

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by visual observation, although, in some cases, magnification is required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination before cleaning is particularly desirable. Cathodic Protection is a method used to control corrosion.

1.2.1 Cathodic Protection

Cathodic Protection (CP) is an electrochemical (half electrical and half chemical) method used to control corrosion of buried or submerged metallic structures. It prevents corrosion by making the protected structure a cathode by installing a more anodic metal (sacrificial or galvanic) anode or a metallic (impressed current) anode connected to a Direct Current (DC) power source. When the proper amount of current is applied to the structure, it becomes a cathode. Since all corrosion occurs at the anode, the structure no longer corrodes. The electrons move in the metallic path (electrical). Reduction (chemical) reactions occur at the surface of the cathode resulting in a hydrogen coating and more alkaline environment. Oxidation (chemical) reactions occur at the surface of the anode resulting in corrosion and a more acidic environment. After a CP system is installed and adjusted to provide adequate protection, the hydrogen coats the defects in the coating and polarizes in the negative direction (to a copper/copper sulfate reference electrode) over time the current and potentials remain relatively stable; changes in currents or potentials indicate a problem. An error-free measurement of negative 850 millivolts DC or more negative to the copper/copper-sulfate reference electrode proves the structure is a cathode and corrosion has been mitigated.

1.2.2 Corrosion

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by visual observation, although, in some cases, magnification is required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination before cleaning is particularly desirable. Some of the eight forms of corrosion are unique, but all of them are more or less

interrelated.

The eight forms of corrosion are: (1) Uniform Attack, (2) Galvanic or Two-Metal Corrosion, (3) Crevice Corrosion, (4) Pitting Corrosion, (5) Intergranular Corrosion, (6) Selective Leaching, (7) Erosion Corrosion, and (8) Stress Corrosion Cracking. This listing is arbitrary but covers practically all corrosion failures and problems. The forms are not listed in any particular order of importance. Below, the eight forms of corrosion are discussed in terms of their characteristics, mechanisms, and preventive measures. Hydrogen damage, although not a form of corrosion, often occurs indirectly as a result of corrosive attack and is, therefore, included in this discussion.

1.2.3 Alternating Current (AC) Corrosion

AC corrosion occurs when there is a source of AC current, typically from a high voltage overhead AC (OHAC) power-line, when there is a low soil resistivity - typically less than 5,000 ohm-cm and there is a very small coating holidays. The AC corrosion pits typically have a tubercle of corrosion product at the pit. AC interference study modeling software can determine the mitigation solution to solve this problem. Typically, AC Corrosion mitigation is done in conjunction with high AC potentials and fault current mitigation.

1.2.4 AC Interference

AC interference occurs when a pipeline parallels a high-voltage overhead AC (OHAC) power-line. An interference study is required when this situation occurs as AC interference can cause high AC potentials along the pipeline (safety), can cause a fault condition between the pipeline and power-line and could cause AC corrosion to occur. The pipeline coating when exposed can have blisters/bubbles caused by the excessive AC. The interference study will use modeling software to determine what combination of interference may be occurring (if any) and provide the mitigation solution to solve the problem.

1.2.5 Uniform Attack

Uniform attack is the most common form of corrosion. It is normally characterized by a chemical or electrochemical reaction that proceeds uniformly over the entire exposed surface or over a large area. The metal becomes thinner and eventually fails. For example, a piece of steel or zinc immersed in dilute sulfuric acid normally dissolves at a uniform rate over its entire surface. A sheet iron roof shows essentially the same degree of rusting over its entire outside surface.

Uniform attack, or general overall corrosion, represents the greatest destruction of metal on a tonnage basis. This form of corrosion, however, is not of great concern from a technical standpoint, because the life of equipment can be accurately estimated on the basis of comparatively simple tests. Merely immersing specimens in the fluid involved is often sufficient. Uniform attack can be prevented or reduced by (1) materials, such as coatings, that reduce contact between metal and electrolytes, (2) inhibitors, or (3) CP.

1.2.6 Galvanic or Two-Metal Corrosion

A potential difference usually exists between two dissimilar-metals when they are immersed in a corrosive or conductive solution. If these metals

are placed in contact (or otherwise electrically connected), this potential difference produces electron flow between them. Corrosion of the less corrosion-resistant metal is usually increased, and attack of the more resistant material is decreased, compared to the behavior of these metals when they are not in contact. The less resistant metal becomes anodic and the more resistant metal becomes cathodic. Usually the cathode or cathodic metal corrodes very little or not at all in this type of couple. Because of the electric currents and dissimilar-metals involved, this form of corrosion is called galvanic, bi-metallic or two-metal, corrosion. Galvanic corrosion is restricted to electrochemical corrosion caused by dissimilar-metal effects. It is electrochemical corrosion, but this document must restrict the term galvanic to dissimilar-metal effects for purposes of clarity.

1.2.7 Crevice Corrosion

Intense localized corrosion frequently occurs within crevices and other shielded areas on metal surfaces exposed to corrosives. This type of attack is usually associated with small volumes of stagnant solution caused by holes, gasket surfaces, lap joints, surface deposits, and crevices under bolt and rivet heads. As a result, this form of corrosion is called crevice corrosion or, sometimes, deposit or gasket corrosion.

1.2.8 Pitting Corrosion

Pitting is a form of extremely localized attack that results in holes in the metal. These holes may be small or large in diameter, but in most cases they are relatively small. Pits are sometimes isolated or so close together that they look like a rough surface. Generally a pit may be described as a cavity or hole with the surface diameter about the same as or less than the depth. Pitting is one of the most destructive and insidious forms of corrosion. It causes equipment to fail because of perforation with only a small percent weight loss of the entire structure. It is often difficult to detect pits because of their small size and because the pits are often covered with corrosion products. In addition, it is difficult to measure quantitatively and compare the extent of pitting because of the varying depths and numbers of pits that may occur under identical conditions. Pitting is also difficult to predict by laboratory tests. Sometimes the pits require a long time (several months or a year) to show up in actual service. Pitting is particularly vicious because it is a localized and intense form of corrosion, and failures often occur with extreme suddenness.

1.2.9 Intergranular Corrosion

Grain boundary effects are of little or no consequence in most applications or uses of metals. If a metal corrodes, uniform attack results since grain boundaries are usually only slightly more reactive than the matrix. However, under certain conditions, grain interfaces are very reactive and intergranular corrosion results. Localized attack at and adjacent to grain boundaries, with relatively little corrosion of the grains, is intergranular corrosion. The alloy disintegrates (grains fall out) or loses its strength. Intergranular corrosion can be caused by impurities at the grain boundaries, enrichment of one of the alloying elements, or depletion of one of these elements in the grain-boundary areas. Small amounts of iron in aluminum, wherein the solubility of iron is low, have been shown to segregate in the grain boundaries and cause intergranular corrosion. It has been shown that, based on surface tension considerations, the zinc content of a brass is higher at the grain

boundaries. Depletion of chromium in the grain-boundary regions results in intergranular corrosion of stainless steels.

1.2.10 Selective Leaching

Selective leaching is the removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in other alloy systems in which aluminum, iron, cobalt, chromium, and other elements are removed. Selective leaching is the general term to describe these processes, and its use precludes the creation of terms such as de-aluminumification, de-cobaltification. Parting is a metallurgical term that is sometimes applied, but selective leaching is preferred.

1.2.11 Erosion Corrosion

Erosion corrosion is the acceleration or increase in rate of deterioration or attack on a metal because of relative movement between a corrosive fluid and the metal surface. Generally, this movement is quite rapid, and mechanical wear effects or abrasion are involved. Metal is removed from the surface as dissolved ions, or it forms solid corrosion products, which are mechanically swept from the metal surface. Sometimes, movement of the environment decreases corrosion, particularly when localized attack occurs under stagnant conditions; this is not erosion corrosion because deterioration is not increased. Erosion corrosion is characterized in appearance by grooves, gullies, waves, rounded holes, and valleys and usually exhibits a directional pattern. In many cases, failures because of erosion corrosion occur in a relatively short time, and they are unexpected largely because evaluation corrosion tests were run under static conditions or because the erosion effects were not considered.

1.2.12 Stress-Corrosion Cracking

Stress-corrosion cracking refers to cracking caused by the simultaneous presence of tensile stress and a specific corrosive medium. Many investigators have classified all cracking failures occurring in corrosive media as stress-corrosion cracking, including failures due to hydrogen embrittlement. However, these two types of cracking failures respond differently to environmental variables. To illustrate, CP is an effective method for preventing stress-corrosion cracking; however, hydrogen-embrittlement may be caused when excessive current is applied, especially on stainless steel. Hence, the importance of considering stress-corrosion cracking and hydrogen embrittlement as separate phenomena is obvious. During stress-corrosion cracking, the metal or alloy is virtually unattacked over most of its surface, while fine cracks progress through it. This cracking phenomenon has serious consequences, since it can occur at stresses within the range of typical design stress.

1.2.13 Exothermic Welding

Exothermic welding is used in CP to connect a copper wire to a metallic structure, usually steel or cast-iron. It is a pyrotechnic composition of copper oxide, aluminum powder and magnesium powder. The magnesium powder is ignited with a spark gun or electronic ignition equipment. The aluminum powder serves as fuel, and melts the copper oxide, which bonds the wire to the structure. Although not explosive, it can create brief bursts of heat and high temperature in a small area.

1.2.14 Error-Free

Potential measurement error due to a voltage drop caused by current flowing through a resistor (the electrolyte) between the reference electrode and the protected structure.

1.3 ADMINISTRATIVE REQUIREMENTS

After award of the contract, but prior to commencement of any work at the site, meet with the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Develop a mutual understanding relative to the administration of the value engineering, the safety program, preparation of the schedule of prices or the earned value report. Review shop drawings, and other submittals, scheduling programming, execution of the work, and clear expectations of the "Interim Department of Defense (DD) Form 1354" submittal. Major subcontractors who will engage in the work must also attend.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Preconstruction Survey

SD-02 Shop Drawings

Drawings; G, D0

Isolation flange kits; G, D0

Anode junction boxes, bonding boxes, and test stations; G, D0

Joint bonds; G, D0

Contractor's Modifications; G, D0

SD-03 Product Data

Qualifications; G, R0

Equipment; G, D0

Anodes; G, D0

Anode junction boxes, bonding boxes, and test stations; G, D0

Dielectric unions; G, D0

Wires; G, D0

Cable and wire; G, D0

Casings, isolation, and seals; G, D0

Shunts; G, D0

Permanent reference electrodes; G, D0

Spare Parts; G, R0

SD-05 Design Data

Design Calculations; G, D0

SD-06 Test Reports

Soil resistivity data; G, D0

Tests and Measurements; G, D0

Contractor's Modifications; G, D0

SD-10 Operation and Maintenance Data

Cathodic Protection System; G, R0

Training Course; G, R0

Cathodic Protection System, Data Package 5; G, R0

SD-11, Closeout Submittals

Initial Cathodic Protection System Field Testing; G, R0

One Year Warranty Period Cathodic Protection System Field Test Report; G, R0

Final Cathodic Protection System Field Test Report; G, R0

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 Spare Parts

After approval of shop drawings, furnish spare parts data for each different item of material and **equipment** specified. The data must include a complete list of parts, special tools, and supplies, with current unit prices and source of supply.

After approval of shop drawings, furnish revised spare parts for any changes made from original submittal. One spare anode of each type must be furnished. In addition, supply information for material and equipment replacement for all other components of the complete system, including **anodes**, cables, splice kits and connectors, corrosion test stations, and any other components not listed above. Demonstrate use of furnished equipment in actual tests during the **training course**. Provide a description of equipment of the pipe-to-soil protected structure and foreign structures at electrical isolation between the utility supplier and the facility piping.

1.6 QUALITY CONTROL

1.6.1 Services of Corrosion Expert

Obtain the services of a corrosion expert to obtain soil resistivity data, design, supervise, inspect, and test the installation and performance of the cathodic protection system. The term "corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried or submerged metallic structures.

All design after award submittals shall be submitted by the corrosion expert for government review. No submittals (e.g., product data) shall be submitted by manufacturers directly to the government.

The corrosion expert must make a minimum of three visits to the project site. The first of these visits will include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the contractor the type of CP required (GACP or ICCP). Once the submittals are approved and the materials delivered, the "corrosion expert" will revisit the site to verify the materials meet submittal requirements, ensure the contractor understands installation practices and that the contractor is capable and qualified to complete the installation.

The corrosion expert will be available (but not necessarily be onsite the entire time) during the installation of the CP system to answer questions, approve any changes or additions required during construction, or to provide recommendations as required. The third visit is to complete the training and demonstrations to applicable personnel on proper testing and maintenance techniques and to complete testing the installed CP systems to ensure it has been installed properly and meets adequate CP criteria. An additional visit is required if the One-Year-Warranty-Period-Testing is required.

1.6.2 Qualifications

The corrosion expert must be accredited or certified by NACE International, as a CP-4 CP Specialist or be a NACE International certified Corrosion Specialist or a registered professional engineer who has certification or licensing that includes education and experience in CP of the type of CP system being installed. The corrosion expert must have not less than five years of experience in the type of CP for buried or submerged metallic structures under this contract. Submit evidence of qualifications of the corrosion expert including their name and qualifications certified in writing to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager prior to the start of construction. Certification must be submitted giving the name of the firm, the number of years of experience, and a list of not less than five of the firm's installations, three or more years old, that have been tested and found satisfactory.

1.7 DELIVERY, STORAGE AND HANDLING

Storage area for corrosion materials will be designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. If materials are not stored in a building, tarps or similar protection must be used to protect material from inclement weather. Resack and add backfill to packaged anodes that are damaged as a

result of improper handling or exposure to rain.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Environmental Requirements

1.8.2 Existing Conditions

Prior to start of any onsite construction activities, perform a [Preconstruction Survey](#) of the project site with the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager, and take photographs showing existing environmental conditions in and adjacent to the site. Submit a report for the record. Include in the report a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the contractor's assigned storage area and access route(s), as applicable. The Contractor and the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager will sign this survey report upon mutual agreement regarding its accuracy and completeness. Protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference that their preservation may cause to the work under the Contract.

1.9 WARRANTY

Provide equipment items that are supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Summary of Services Required

The scope of services shall include, but shall not be limited to, the following:

- a. Provide design calculations for each piping system and component requiring cathodic protection. Submit calculations determining the number and type of anodes to be used. Provide calculations and/or justification in accordance with UFC 3-570-06 for each metallic piping system and component not to be provided with cathodic protection.
- b. Conduct site investigations, soil resistivity measurements, water corrosivity (pH) tests, etc.
- c. Design of the cathodic protection systems.
- d. Installation of the cathodic protection systems.
- e. Measurement and testing of the cathodic protection systems.
- f. Adjustment of the cathodic protection system as a result of failed testing.

g. Training.

2.1.2 Systems And Components Requiring Cathodic Protection

Cathodic protection shall be provided for systems and components where required by UFC 3-570-06 or NACE criteria. Some of the systems and components requiring cathodic protection shall include, but not be limited to the following:

- a. Pipes under the floor slab or foundations.
- b. PIV.
- c. Shutoff valves.
- d. Metallic pipe extended from aboveground locations.
- e. Each connector or change-of-direction device.
- f. Any metallic pipe component or section.
- g. Backflow preventer.

2.1.3 Design Requirements

2.1.3.1 Electrical Isolators

Isolators are required to isolate the pipes from any other structure. Provide isolators at all locations where the indicated pipes contact any other metallic structure. Provide locations and detailed drawings of required installations. Include any requirements for lightning protection, test stations, surge protection, or other requirements and include locations and details in design drawings.

2.1.3.2 Anode and Bond Wires

Provide magnesium anodes at uniform distances along the metallic pipelines. Use test stations for these anodes. Provide these anodes in addition to anodes for the pipe under concrete slab and casing requirements. For each cathodic system, provide metallic components and structures that are electrically continuous by installing bond wires between the various structures. Bonding of existing buried structures may also be required to preclude detrimental stray current effects and safety hazards. Return stray current to its source without damaging structures intercepting the stray current. Provide electrical isolation of underground facilities in accordance with acceptable industry practice. All tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

2.1.3.3 Surge Protection

Install approved zinc grounding cells or sealed weatherproof lightning and surge arrestor devices across isolation flanges or fittings installed in underground piping. Provide gapless, self-healing, solid state type arrestor. Provide zinc anode composition conforming to ASTM B418, Type II. Provide number 4 AWG copper lead wires with High Molecular Weight Polyethylene (HMWPE) insulation. Zinc grounding cells must be prepackaged in backfill. Lightning arrestors or zinc grounding cells are not required

for isolation flanges on metallic components used on non-metallic piping systems.

2.1.3.4 Non-metallic Pipe System

In the event pipe other than metallic pipe is approved and used in lieu of metallic pipe, protect all metallic components of this pipe system with CP. Submit detailed drawings of CP for each component to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager for approval within 45 days after date of receipt of notice to proceed, and before commencement of any work.

Provide the number of anodes required by the design calculations, UFC 3-570-06, NACE criteria, and this Specification. As a minimum, protect each component with 2 magnesium anodes. The magnesium anodes shall be located on each side of the metallic component and routed through a test station.

2.1.3.5 Coatings

Coatings for metallic components will be as required by this specification and by the "Corrosion Expert". These metallic fittings will include fire hydrants, tees, elbows, and valves. Coatings must be selected, applied, and inspected as specified by the "Corrosion Expert". All coatings must be in accordance with all applicable Federal, State, and local regulations. Unbonded coatings must not be used with CP.

2.1.3.6 Tracer Wire

When a non-metallic pipeline is used to extend or add to an existing metallic line, exothermic-weld No. 8 AWG copper wire with THHN insulation to the existing metallic line and run the length of the new non-metallic line. Use this wire as a locator tracer wire and to maintain continuity to any future extensions of the pipeline.

2.1.3.7 Drawings

Submit six copies of detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, contractor's modifications, results of system design calculations including soil-resistivity, installation instructions and certified test data showing location of anodes and stating the maximum recommended anode current output density. Include in the detail drawings complete wiring and schematic diagrams, isolation fittings, test stations, permanent reference electrodes and bonding and any other details required to demonstrate that the system has been coordinated and will function properly as a unit. Reference locations to two permanent facilities or mark points. Provide one electronic copy and digital photos of the completed installation.

2.1.3.8 Location of Test Stations

Provide test stations. Provide buried isolation joints with test wire connections brought to a test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations as follows:

- a. At 1,000-foot intervals or less.

- b. Where the pipe or conduit crosses any other metal pipe.
- c. At both ends of casings under roadways and railways.
- d. Where both sides of an isolation joint are not accessible above ground for testing purposes.

2.1.3.9 Electrical Isolation of Structures

As a minimum, provide isolating flanges or unions at the following locations:

- a. Connection of new metallic piping or components to existing piping.
- b. Pressure piping beneath floor slab to a building.

Provide isolation at metallic connection of all lines to existing system and where connecting to a building. Additionally, provide isolation between water or gas or forced main line; and foreign pipes that cross the new lines within 10 feet. Install isolation fittings, including isolating flanges and couplings, aboveground or in a concrete pit.

2.1.3.9.1 Gas Distribution Piping

Provide electrical isolation at each building riser pipe to the pressure regulator, at all points where a short to another structure or to a foreign structure may occur, and at other locations as indicated on the drawings.

2.1.3.9.2 Isolation Joint Testing

An isolator checker or insulation tester will be used for isolation or insulating joint (flange or dielectric) electrical testing.

2.1.3.9.3 Underground Structure Coating

This coating specification takes precedence over any other project specification and drawing notes, whether stated or implied, and also applies to the pipeline or tank supplier. Variance in coating quality is not allowed by the contractor or Base Construction Representative without the written consent of the designer. All underground metallic pipelines and tanks to be cathodically protected must have a high quality factory-applied coating. This includes all carbon steel, cast-iron and ductile-iron pipelines or vessels. Select, apply, and inspect coatings as specified. If non-metallic pipelines are installed, coat all metallic fittings on pipe sections in accordance with this specification section.

- a. The nominal coating thickness for the metallic pipe joint or other component coating must be as determined by the "Corrosion Expert".
- b. Apply pipe and joint coating for factory applied or field repair material as recommended by the manufacturer. Coating must be one of the following:
 - (1) Continuously extruded polyethylene and adhesive coating system.
 - (2) Polyvinyl chloride pressure-sensitive adhesive tape.
 - (3) High density polyethylene/bituminous rubber compound tape.
 - (4) Butyl rubber tape.
 - (5) Coal tar epoxy.

2.1.3.9.4 Field Joints

Coat all field joints with materials compatible with the pipeline coating compound. Apply the joint coating material to an equal thickness as the pipeline coating. Do not use unbonded coatings for these buried metallic components. This includes the elimination of all unbonded polymer wraps or tubes. Once the pipeline or vessel is set in the trench, conduct an inspection of the coating. This inspection must include electrical holiday detection. Repair any damaged areas of the coating. The Contracting Officer or the Contracting Officer's Representative, Technical Expert or Project Manager must be asked to witness inspection of the coating and testing using a holiday detector.

2.1.3.9.5 Inspection of Pipe Coatings

Any damage to the protective coating during transit and handling must be repaired before installation. After field coating has been applied, inspect the entire pipe using an electric holiday detector in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector must be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Upon detection, immediately repair all holidays in the protective coating. Occasional checks of holiday detector, operation will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Provide all labor, materials, and equipment necessary for conducting the inspection.

2.1.3.9.6 Protective Coating for Aboveground Piping System

Provide finish painting conforming to the applicable paragraph of Section 09 90 00 PAINTS AND COATINGS and as follows:

2.1.3.9.7 Ferrous Surfaces

Touch-up shop-primed surfaces with ferrous metal primer. Solvent-clean surfaces that have not been shop-primed. Surfaces that contain loose rust, loose mill scale, and other foreign substances must be mechanically-cleaned by power wire-brushing and primed with ferrous metal primer. Finish primed surface with two coats of exterior oil paint and vinyl paint.

2.2 EQUIPMENT

2.3 COMPONENTS

2.3.1 Test Stations

2.3.1.1 Flush Mounted

NEMA ICS 6. Metallic or non-metallic with terminal board, terminal posts and lockable lid. A non-metallic enclosure must be molded of glass filled polycarbonate and urethane coated or Acrylonitrile Butadiene Styrene (ABS) plastic. The unit must be of standard design, manufactured for use as a CP test station, complete with cover, terminal board, shunts, and brass or Type 304 stainless steel hardware. The terminal board must be removable for easy access to wires. The cover must have a cast in legend "CP TEST."

2.3.2 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic 1/8 inch thick with dimensions as indicated. Insulated terminal boards must have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, reference electrodes and coupons).

2.3.3 Anode Junction Boxes

2.3.3.1 Enclosure

NEMA ICS 6, Type 3R enclosure with clamped cover and padlocked hasp. Enclosure must be of galvanized steel construction with terminal board and labeled with nameplate. Provide nameplate in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3.3.2 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic 1/8 inch thick with dimensions as indicated. Insulated terminal boards must have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes).

2.4 MATERIALS

2.4.1 Galvanic Anodes

Provide anodes as required by the design calculations, UFC 3-570-06, NACE criteria, and this Specification.

2.4.1.1 Magnesium Anodes

2.4.1.1.1 Anode Composition

Anodes must be of high-potential magnesium alloy, made of primary magnesium obtained from sea water or brine, and not made from scrap metal. Magnesium anodes must conform to ASTM B843 and to the following analysis (in percent) otherwise indicated:

Aluminum	0.010 percent
Manganese	0.50 to 1.30 percent max
Zinc	0.05 percent max
Silicon	0.05 percent max

Copper	0.02 percent max
Nickel	0.001 percent max
Iron	0.03 percent max
Other impurities	0.05 each or 0.3 percent max total
Magnesium	Remainder

Furnish spectrographic analysis on samples from each heat or batch of anodes used on this project.

2.4.1.1.2 Packaged Anodes

Provide anodes in packaged form with the anode surrounded by specially-prepared quick-wetting backfill and contained in a water permeable cloth or paper sack. Anodes must be centered by means of spacers in the backfill material.

The backfill material will have the following composition, unless otherwise indicated:

Material	Approximate Percent by Weight
Gypsum	75
Bentonite	20
Sodium Sulfate	5
Total	100

2.4.1.2 Zinc Anodes

ASTM B418, Type II.

2.4.2 Wire and Cable

2.4.2.1 Anode Lead Wire

Wire must be No. 10 AWG solid copper wire, not less than 10 feet long, without any splices, complying with NFPA 70, Type Thermoplastic Heat and Water-resistant Nylon-coated (THHN) Rubber Heat (resistant) Wire (RHW) insulation. Connecting wires for anodes will be factory installed with the place or emergence from the anode in a cavity-sealed flush with a dielectric sealing compound.

2.4.2.2 Connected Anodes

UL 83, Type THWN/THHN solid copper conductors, not less than 10 AWG, of sufficient length to extend to the accompanying junction box without splicing. Anode lead wire will be factory installed.

2.4.2.3 Anode Header Cable

Cable for anode header and distribution will be stranded copper wire with

type CP HMWP, 7/64 inch thick insulation, 600-volt rating.

2.4.2.4 Structure (Negative) Cable

Structure connecting wire must be AWG stranded copper wire with type THHN/THWN insulation, 600 volt rating. Copper conductors conforming to ASTM B3 and ASTM B8.

2.4.2.5 Test Wires

Test wires must be No. 12 AWG stranded copper wire with NFPA 70 Type Thermoplastic Wire (TW) or RHW or polyethylene insulation. Copper conductors conforming to ASTM B3 and ASTM B8.

2.4.2.6 Joint and Continuity Bond Cables

Provide bonds across joints or any electrically discontinuous connections in the piping, and other pipes and structures with other than welded or threaded joints included in this CP system. Unless otherwise specified, bonds between structures and across joints in pipe with other than welded or threaded joints must be with No. 4 AWG stranded copper cable with polyethylene insulation. Bonds between structures must contain sufficient slack for any anticipated movement between structures. Bonds across pipe joints must contain a minimum of 4 inch of slack to allow for pipe movement and soil stress. Bonds must be attached by exothermic welding. Exothermic weld areas must be insulated with coating compound and approved by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Continuity bonds must be installed as necessary to reduce stray current interference. Additional joint bonding must be done where determined during construction or testing or as directed. Joint bonding must include excavation and backfilling. There must be a minimum of 2 continuity bonds between each structure and other than welded or threaded joints. Electrical continuity must be tested across joints with other than welded or threaded joints and across metallic portions of sewage lift stations and water booster stations. Copper conductors conforming to ASTM B3 and ASTM B8.

2.4.2.7 Resistance Bond Wires

Resistance bonds must be adjusted for minimum interference while achieving the criteria of protection. Alternate methods may be used when approved.

2.4.2.8 Polyethylene Insulation

Polyethylene insulation must comply with the requirements of ASTM D1248 and of the following types, classes, and grades:

2.4.3 Cable and wire Identification Tags

Laminated plastic material with black letters on a yellow background. Print letters and numbers a minimum of 3/16 inch in height. Provide identifier legend.

2.4.4 Anode Connection

2.4.4.1 End-Connected Anode

Drill or Cast a recess 6 inches deep in one end of the anode. Attach the lead wire to the anode with an anchor device. Not more than 1/2 inch of

bare wire must protrude from the anchor device. Attachment must withstand a 325 pound pull without loosening the wire or anchor device. Fill the recess with an epoxy sealing compound , leaving sufficient space for a plug. Provide non-metallic plug flush with the anode end surface. Cable-to-anode contact resistance must not exceed 0.02 ohms.

2.4.4.2 Center-Connected Anode

Attach the lead wire to the center of the anode with an anchor device suitably fastened to the wire. Not more than one inch of bare wire must protrude from the anchor device. Encapsulate each side of the connection point with a minimum of 6 inches of high voltage insulating compound mastic and 4 inches of epoxy resin. Attachment must withstand 900 pounds pull without loosening the wire or anchor device. Provide a non-metallic plug flush with the anode end to prevent chaffing of the anode lead wire. Cable-to-anode contact resistance must not exceed 0.02 ohms.

2.4.5 AC Mitigation Materials

If required, AC mitigation materials typically consist of a mitigation material either zinc ribbon or copper cable, interconnecting coated copper cables, solid state decouplers to control the AC current flow and test stations.

2.4.6 Backfill Material

The backfill material must have the following composition, unless otherwise indicated:

Material	Approximate Percent by Weight
Gypsum	75
Bentonite	20
Sodium Sulfate	5
Total	100

2.4.7 Permanent Reference Electrodes

Permanent reference electrodes must be copper/copper-sulfate specifically manufactured for underground use with an ion trap to minimize contamination of the electrode. Must never need recharging, maintenance, or recalibration. Must have impregnated membrane which keeps electrode electrolytes from drying out or getting the reference electrode electrolyte contaminated. Must have ion trap to prevent reference electrode damage from hydrogen sulfide or excess chloride ions. Provide electrodes with No. 10 AWG, THHN cable of sufficient length to extend to the test station without splicing. Reference electrodes will have a minimum 20-year life, stability of plus or minus 5 millivolts under 3 microamp load. The manufacturer must calibrate the PRE to 316 mV plus or minus 10mV referenced to a standard hydrogen electrode (SHE) and provide a calibration certificate detailing the results of the calibration. Procedures for evaluating the accuracy annually must be included in the Operation and Maintenance Manual.

2.4.8 Pavement Inserts

Pavement insert must be a non-metallic flush type test station without terminal board, and must allow a copper/copper sulfate reference electrode to contact the electrolyte beneath the pavement surface.

2.4.9 Coupons

Coupons must match the material of the structure, with integrated connection(s) with electrical wire(s) and be designed, manufactured and procured for use as a corrosion coupon, IR-Free reference electrode, or AC reading electrode.

2.4.10 Zinc Grounding Cells

Two Zinc anodes separated with 1 inch isolating spacers. Minimum 10 feet of #6 AWG HMWPE CP cable crimped securely to each anode. Both anodes centered in one cloth bag and surrounded with low resistance backfill mixture consists of 75 percent hydrated gypsum, 20 percent bentonite, and 5 percent sodium sulfate.

Element	Content Percent	
	MIL-A-18001 ASTM B418 Type I	ASTM B418 Type II
Al	0.1 - 0.5 percent	0.005 percent max
Cd	0.02 - 0.07 percent	0.003 percent max
Fe	0.005 percent max	0.0014 percent max
Pb	0.006 percent max	0.003 percent max
Cu	0.005 percent max	0.002 percent max
Zinc	Remainder	Remainder

Bare Weight		Width		Height		Length		Total Packaged Weight	
kg	pounds	mm	inches	mm	inches	mm	inches	kg	pounds
	5		1.4		1.4		10		20
	12		1.4		1.4		24		40
	15		1.4		1.4		30		50
	15		2.0		2.0		15		36
	18		1.4		1.4		36		55
	30		1.4		1.4		60		86
	30		2.0		2.0		30		67

Bare Weight		Width		Height		Length		Total Packaged Weight	
kg	pounds	mm	inches	mm	inches	mm	inches	kg	pounds
	45		2.0		2.0		45		100
	60		2.0		2.0		60		120

2.4.11 Isolation Flange Kits

Provide full-faced gaskets, isolating sleeves and washers, and steel washers. Provide isolation flange kits rated for operation at the rated pressure and temperature.

2.4.11.1 Gaskets

ASME B16.21. Neoprene faced phenolic material for operation at 450 degrees F.

2.4.11.2 Isolating Washers and Sleeves

Two sets 1/8 inch laminated phenolic for operation at 450 degrees F. Isolating washers must fit within the bolt facing on the flange over the outside of the fabric reinforced phenolic sleeve.

2.4.11.3 Washers

Steel, cadmium plated, to fit within the bolt facing on the flange.

2.4.12 Steel Flanges and Bolting

2.4.12.1 Steel Flanges

ASME B16.5.

2.4.12.2 Bolting

ASTM A307, Grade B for bolts; ASTM A194/A194M, Grade 2 for nuts. Dimensions: ASME B18.2.1 for bolts, ASME B18.2.2 for nuts. Threads: ASME B1.1, Class 2A fit for bolts, Class 2B fit for nuts. Bolts must extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at the roof of threads.

2.4.13 Dielectric Unions

ASME B16.39, Class as required for dimensional, strength, and pressure requirements. Insulation barrier must limit galvanic current to one percent of the short-circuit current in a corresponding metallic joint. Provide insulating material impervious to water.

2.4.14 Isolation and End Seals

2.4.14.1 Casing Isolator/Centralizer

High density (linear), injection molded virgin Polyethylene positive electrical isolation, high abrasion resistance and low coefficient of friction.

2.4.14.2 End Seals

Ethylene Propylene Diene Monomer (EPDM) Neoprene rubber end seals, thickness of [1/8 inch](#) or more, with Stainless Steel Pipe Clamps per end seal, [1/8 inch](#) thick and [1/2 inch](#) wide or more.

2.5 ACCESSORIES

2.5.1 Conduit

[UL 6](#), rigid galvanized steel, Outlet boxes: [UL 514A](#) and fittings [UL 514B](#), threaded hubs. [NEMA TC 2](#), Type EPC-40-PVC. Non-metallic conduit must conform to [NEMA TC 2](#).

2.5.2 Joint, Patch, Seal, and Repair Coating

Sealing and dielectric compound must be a black, rubber based compound that is soft, permanently pliable, tacky, moldable, and unbacked. Compound will be applied as recommended by the manufacturer, but not less than [1/2-inch](#) thick. Pressure-sensitive vinyl plastic electrical tape and rubber insulated tape must conform to [UL 510](#).

2.5.3 Underground Splices

Provide splices with a compression connector on the conductors, and insulation and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with [ANSI C119.1](#).

2.5.3.1 Cast-Type Splice

Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy resin insulating material applied by a gravity poured method or pressure injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.

2.5.3.2 Gravity-Poured Splice

Gravity-poured method must employ materials and equipment contained in and approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.

2.5.3.3 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which must be applied by a clean burning propane gas torch.

2.5.4 Electrical Isolation of Structures

2.5.4.1 Electrically Isolating Pipe Joints

Electrically isolating pipe joints will be of a type that is in regular factory production.

2.5.4.2 Electrically Isolating Couplings

Electrically isolating couplings will be of a type that has a published maximum electrical resistance rating given in the manufacturer's literature. Cradles and seals will be of a type that is in regular factory production made for the purpose of electrically isolating the carrier pipe from the casing and preventing the incursion of water into the annular space.

2.5.5 Electrical Insulating Coating

Heat-shrinkable tape.

2.5.6 Buried Cable Warning and Identification Tape

Polyethylene tape, manufactured for warning and identification of buried cable and conduit. Tape must be 3 inches wide, Yellow in color and read "Caution Buried Cable Below" or similar. Color and lettering must be permanent and unaffected by moisture or other substances in backfill materials.

2.5.7 Electrical Connection to Structures

2.5.7.1 Exothermic Welds

Electrical connections to metallic structures must be made using exothermic welds in strict accordance with the manufacturer's recommendations.

2.5.7.2 Electrical-Shielded Arc Welds

Electrical-shielded arc welds must be approved for use on steel pipe by shop drawing submittal action.

2.5.7.3 Brazing

Brazing will be as specified by manufacturer using specialized equipment designed for that purpose.

2.5.8 Electrical Tape

Pressure-sensitive vinyl plastic electrical tape and rubber insulated tape must conform to UL 510.

2.5.9 Exothermic Weld Kits

Exothermic weld kits specifically designed by the manufacturer for exothermic welding wires to metallic surfaces. Molds must be for specific type of metallic structure (steel, cast iron), specific diameter of pipe or metallic surface and specific size (AWG) and type of wire (solid, stranded).

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 Tests of Components

Perform a minimum of four tests at each metallic component in the piping system. Two measurements must be made directly over the anodes and the other two tests must be over the outer edge of the component, but at the farthest point from the anodes. Provide a field drawing showing the component, the structure, all components of the CP system and their relationship to each other. Also provide a narrative describing how the CP system will work and the testing at each component. Components requiring CP must include but not be limited to the following:

- a. Pipes beneath the floor slab or foundations.
- b. Post Indicator Valve (PIV).
- c. Shutoff valves.
- d. Metallic pipes extended from aboveground locations.
- e. Connectors or change-of-direction devices.
- f. Metallic pipe components or sections.
- g. Backflow preventers.

2.6.2 Electrical Potential Measurements

Make all potential tests at a minimum of 10 foot intervals witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Provide submittals identifying test locations on separate drawings, showing all metal to be protected and all CP equipment. Distinguish and identify test points, equipment, and protected metal.

2.6.3 Non-Destructive Testing of Anodes

Contractor must perform the tests in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. One anode of each type will be chosen at random for non-destructive testing and will be submerged in a container of fresh water for about 30 minutes. Contractor must then measure the anode-to-water potential difference between a calibrated copper/copper sulfate reference electrode. Potential differences must generally be within the following ranges:

Anode Type	DC Volts to Calibrated Cu/CuSO4 Reference Electrode
High Potential Magnesium	More Negative than Negative 1.65 Volts DC
Standard Magnesium	More Negative than Negative 1.4 Volts DC
Zinc	More Negative than Negative 1.0 Volts DC

Anode Type	DC Volts to Calibrated Cu/CuSO4 Reference Electrode
Aluminum	More Negative than Negativevee 1.0 Volts DC

Failure of the test anode to conform to this specification can be cause for rejecting all anodes from the same lot as the test anode. The contractor must mark all rejected anodes on the ends with a 6 inch high "X" using yellow spray paint. Failed anodes must be removed from the job site by the end of the day. The contractor must replace any rejected anodes at the contractor's expense. The destructive testing provision must also apply to replacement anodes as well.

2.6.4 Destructive Testing of Anodes

Contractor must perform the tests in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Contractor must include the cost of an additional anode with the longest lead wire for the destructive test in the contractor's bid. One completed anode of each type with lead wires will be chosen at random for destructive testing and must be submitted to a static pull test. Anode wire connections must have sufficient strength to withstand a minimum tensile load of 300 pounds. The anode must be cut into sections or broken with a sledgehammer to verify conformance with this specification. Such items as anode-to-wire connection, complete encapsulation of the wire connector, and wire to anode electrical resistance must be checked. Failure of the test anode to conform to this specification can be cause for rejecting all anodes from the same lot as the test anode. The contractor must mark all rejected anodes on the ends with a 6 inch high "X" using yellow spray paint. Failed anodes must be removed from the job site by the end of the day. The contractor must replace any rejected anodes at the contractor's expense. The destructive testing provision will also apply to replacement anodes as well.

PART 3 EXECUTION

3.1 SAFETY PRECAUTIONS AND HAZARDOUS LOCATIONS

Any personnel performing operations that will generate heat, sparks, or flame in hazardous locations must first perform adequate safety precautions. A trained responsible person must ensure the area is safe to perform the operation. Required actions include ensuring adequate ventilation before work starts, air monitoring, and a fire watch must be provided and remain for 30 minutes after the operation is completed. A minimum of 20 pound ABC type fire extinguisher must be available and must be inspected before each use. Equipment being used must be inspected and used in accordance with manufacturer recommendations. Combustibles that are in the work area(s) must be moved or if they cannot be moved, be covered with fire retardant welding blankets. When performing exothermic welding, properly sized charges and inspection of the structure condition must be accomplished to ensure a safe operation.

3.2 INSTALLATION

3.2.1 Excavation and Trenching

Perform trenching and backfilling in accordance with Section 31 00 00 EARTHWORK. In the areas of the anode beds, all trees and underbrush will

be cleared and grubbed to the limits shown or indicated. In the event rock is encountered in providing the required depth for anodes, determine an alternate approved location and, if the depth is still not provided, submit an alternate plan to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Alternate techniques and depths must be approved prior to implementation.

3.2.2 Anode Excavation

- a. Excavate hole to a minimum 3 inches larger than the packaged anode diameter.

3.2.3 Lead Wire Trench

- b. Excavate lead wire trench to 24 inches deep.

3.3 ANODES AND LEAD WIRE

3.3.1 Anode Installation

Unless otherwise authorized, installation must not proceed without the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Anodes of the size specified must be installed to the depth indicated and at the locations shown. Locations may be changed to clear obstructions with the approval of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Anodes will be installed in sufficient number and of the required type, size, and spacing to obtain a uniform current distribution over the surface of the structure. The anode system will be designed for a life of 25 years of continuous operation. Anodes must be installed as indicated in a dry condition after any plastic or waterproof protective covering has been completely removed from the water permeable, permanent container housing the anode metal. The anode connecting wire must not be used for lowering the anode into the hole. The annular space around the anode must be backfilled with fine earth in 6 inch layers and each layer must be hand tamped.

3.3.1.1 Single Anodes

Single anodes, spaced as shown, will be connected to the pipeline, allowing adequate slack in the connecting wire to compensate for movement during backfill operation.

3.3.1.2 Group of Anodes

Groups of anodes, in quantity and location shown, must be connected to an anode header cable. The anode header cable must make contact with the structure to be protected only through a test station. Anode lead connection to the anode header cable must be made by an approved crimp connector or exothermic weld and splice mold kit with appropriate potting compound.

3.4 INSTALLATION DETAILS

3.4.1 Anode Installation

Do not lift or support anode by the lead wire. Where applicable, remove manufacturer's plastic wrap/bag from the anode. Exercise care to preclude damaging the cloth bag and the lead wire insulation. Center the packaged

anode in the hole with native soil in layers not exceeding 6 inches. Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 6 inches above the top of the anode, pour at least ten gallons of water into the hole to saturate the anode backfill and surrounding soil. Anodes must not be backfilled prior to inspection and approval by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.4.2 Lead Wire Installation

Cover the lead wire trench bottom with a 3 inch layer of sand or stone free earth. Center wire on the backfill layer. Do not stretch or kink the conductor. Place backfill over wire in layers not exceeding six inches deep. Compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter and refuse in backfill. Place cable warning tape within 18 inches of finished grade, above cable and conduit.

3.4.2.1 Lead Wire Connections

Connect anode lead wire(s) to the test station terminal board(s) . The coating must be completely cured before backfilling. Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.

3.4.2.2 Field Drawing

Complete a field drawing of each anode installation showing location of anode, test station, depth of anode, color and size of anode lead wire and any other pertinent details. Submit copy with daily report to the government.

3.4.2.3 Metallic Underground Pipeline Connection

To facilitate periodic electrical measurements during the life of the sacrificial anode system and to reduce the output current of the anodes, if required, all anode lead wires must be connected to a test station and buried a minimum of 24 inches in depth. The cable must be No. 10 AWG, stranded copper, polyethylene or RHW-USE insulated cable. The cable must make contact with the structure only through a test station. Resistance wire must be installed between the cable and the pipe cable, in the test station, to reduce the current output, if required. Anode connections, except in the test station, must be accomplished by exothermic welding, and must be insulated by means of at least three (3) layers of electrical tape; and all lead wire connections must be installed in a moisture-proof splice mold kit and filled with epoxy resin. Lead wire-to-structure connections must be accomplished by an exothermic welding process. All welds must be in accordance with the manufacturer's recommendations. A backfill shield filled with a pipeline mastic sealant and material compatible with the coating must be placed over the weld connection and be of such diameter as to cover the exposed metal adequately. Anodes must be installed at a minimum of 8 feet and a maximum of 10 feet from the structure to be protected.

Contractor must take proper safety precautions prior to and during welding to live pipelines . Contractor must notify the activity Fuel Office via the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of three days before performing exothermic welding to live lines. Exothermic welding must be conducted with product flowing through the pipeline to eliminate vapor

spaces within the pipe and to dissipate the heat on the pipe. Exothermic weld charges for connections to live lines must be limited to a maximum 15 gram charge to prevent burning through the pipe wall. Exothermic weld connections must be spaced a minimum of 6 inches apart. In the event of an unsuccessful weld, the new weld location must be located a minimum of 6 inches from the unsuccessful weld and any other existing welds. Contractor must obtain the services of a certified safety professional to approve the contractor's exothermic welding safety procedures. Results of this consultation must be included in the Contractor's Daily Report.

3.4.3 Underground Pipe Joint Bonds

Underground pipe having other than welded or threaded coupling joints must be made electrically continuous by means of a bonding connection installed across the joint.

3.4.4 Anode Junction Boxes

Provide junction boxes and mark each of the wires terminating in each box.

3.4.5 Bonding Boxes

Provide structure bonding boxes in locations where the protected structure crosses or comes into close proximity to other metal structures that are unprotected or protected by its own electrically isolated CP system(s).

3.4.6 Test Stations and Permanent Reference Electrodes

Provide buried isolation joints with test wire connections brought to a test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations and permanent reference electrodes as follows:

- a. At 1000 foot intervals.
- b. At all isolation joints.
- c. At both ends of casings.
- d. Where the pipe crosses any other metal pipes.
- e. Where the pipe connects to an existing piping system.
- f. Where the pipe connects to a dissimilar-metal pipe.

Do not fill the bottom of the test station with concrete unless otherwise specified. Do not place rubbish, scrap or other debris into the test station.

3.4.7 Permanent Reference Electrode Verification

Verify permanent reference electrodes against a calibrated portable electrode in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager before installation. Verify in a non-metallic container of water. Permanent electrode must measure a reference potential agreeing with that measured by the portable electrode within plus or minus 0.010 volts when the sensing windows of the two electrodes being compared are not more than 1/6 inch apart but not touching. Remove permanent reference electrodes not

within this potential range from the construction site by the end of the day and replace at the contractor's expense. The testing provision applies to replacement permanent reference electrodes as well.

3.4.7.1 Field Drawings

Complete a field drawing of each anode installation showing location of anode, depth of anode, color and size of anode lead wire and any other pertinent details, test station location and diagram, Underground Pipe Joint bond locations and details, Anode Junction Box Location and details, Bonding Box location and details, Permanent Reference Electrode locations, Location of all Electrical Isolations. Submit copy with daily report to the government.

3.5 ELECTRICAL ISOLATION OF STRUCTURES

3.5.1 Isolation Fittings

Isolating fittings, including isolating flange kits, dielectric unions and couplings, must be installed aboveground, or within manholes, wherever possible. Where isolating joints must be covered with soil, they must be fitted with a proper joint cover specifically manufactured for covering the particular joint, and the space within the cover filled with hot coal-tar enamel or hot petrolatum wax. Isolating fittings in lines entering buildings must be located at least 12 inch above grade of floor level, when possible. Isolating joints must be provided with grounding cells to protect against over-voltage surges or approved surge protection devices. The cells must provide a low resistance across isolating joint without excessive loss of cathodic current.

3.5.2 Dielectric Unions

Cut pipe ends square, remove fins and burrs, cut taper pipe threads in accordance with ASME B1.20.1. Provide isolation unions as indicated. Work piping into place without springing or forcing. Apply joint compound or thread tape to male threads only. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Cover unions with an electrically insulating coating.

3.5.3 Gas Distribution Piping

Electrical isolation will be provided at each building riser pipe to the pressure regulator, at all points where a short to another structure or to a foreign structure may occur, and at other locations as indicated on the drawings. If an isolating joint is located inside a vault, the pipe must be sleeved when entering and leaving the vault. A non-metallic sleeve is to be used.

3.5.4 Joint Bonds

Provide joint bonds on metallic pipe to and across buried flexible couplings, mechanical joints, flanged joints and joints not welded or threaded to provide electrical continuity. Connect bond wire(s) to the structure(s) by use of exothermic weld kit(s). Clean the structure surface by scraping, filing or wire brushing to produce a clean, bright surface. Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 2 pound hammer. Cover connections with an electrically insulating coating.

3.5.5 Casings, Isolation, and Seals

Where the pipeline is installed in a casing under a roadway or railway, isolate the pipeline from the casing, and seal the annular space against intrusion of water.

3.6 FIELD QUALITY CONTROL

Field tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative 5 days prior to performing each field test. Quality control for the [cathodic protection system](#) must consist of the following:

- a. Initial field testing by the contractor upon construction.
- b. Government Field Testing after contractor initial field test report submission.
- c. Warranty period field testing by the contractor.
- d. Final field testing by the contractor after one year of service.

3.6.1 Tests and Measurements

3.6.1.1 Native Potentials

Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five (5) working days prior to each test. Base potential tests: At least one week after backfilling of the pipe and installation of the anodes, but before connection of anodes to the structure, measure base (native) structure-to-electrolyte potentials of the pipe . Perform measurements at anode junction boxes, test stations and other locations suitable for test purposes (such as service risers or valves), at intervals not exceeding [100 feet](#) with readings at each end point and the midpoints as a minimum. The locations of these measurements must be identical to the locations specified for potential measurements with anodes connected. Use the same measuring equipment that is specified for measuring protected potential measurements.

3.6.1.2 Protected Potentials

Systems must be tested and inspected by the contractor's corrosion engineer in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager corrosion protection engineer or an approved representative. Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five working days prior to each test. At least one week after native potential testing and connection of anodes to the structure, measure protected structure-to-electrolyte potentials. The locations of these measurements must be identical to the locations specified for native potential measurements. Use the same measuring equipment that is specified for measuring protected potential measurements. Record test data, including date, time, and locations of testing and submit report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

Contractor must correct and retest, at the contractor's and Technical Expert's expense, deficiencies in the materials and installation observed by these tests and inspections.

3.6.1.3 Isolation Testing

Before the anode system is connected to the pipe, an isolation test must be made at each isolating joint or fitting. This test will demonstrate that no metallic contact, or short circuit exists between the two isolated sections of the pipe. Any isolating fittings installed and found to be defective must be reported to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.6.1.4 Isolation Tester

An Isolation Tester designed and manufactured for use in CP, using the continuity check circuit, must be used for all isolating joint (flange) electrical testing. Testing must conform to the manufacturer's operating instructions. Test must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. An isolating joint that is good will read full scale on the meter. If an isolating joint is shorted, the meter pointer will be deflected or near zero on the meter scale. Location of the fault will be determined from the instructions, and the joint must be repaired.

3.6.1.5 Anode Output

As the anodes or groups of anodes are connected to the pipe, current output will be measured with an approved clamp-on milliammeter, calibrated shunt with a suitable millivoltmeter or multimeter, or a low resistance ammeter. (Of the three methods, the low-resistance ammeter is the least desirable and most inaccurate. The clamp-on milliammeter is the most accurate.) The values obtained and the date, time, and location must be recorded.

3.6.1.6 Reference Electrode Potential Measurements

Upon completion of the installation and with the entire CP system in operation, electrode potential measurements must be made using a copper/copper sulfate reference electrode and a potentiometer-voltmeter, or a direct-current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements must be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements must be recorded. No less than eight (8) measurements will be made over any length of line or component. Additional measurements will be made at each distribution service riser, with the reference electrode placed directly over the service line.

3.6.1.7 Casing Tests

Before final acceptance of the installation, the electrical isolation of carrier pipe from casings must be tested and any short circuits corrected.

3.6.1.8 Holiday Test

Any damage to the protective coating during transit and handling must be repaired before installation. After field-coating has been applied, the entire pipe must be inspected by an electric holiday detector with

impressed current in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector will be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective coating must be repaired upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Labor, materials, and equipment necessary for conducting the inspection must be furnished by the contractor. The coating system must be inspected for holes, voids, cracks, and other damage during installation.

3.6.1.9 Stray Current Measurements

Before final acceptance of the installation, stray current tests must be performed on any foreign pipes in close proximity to the installed anodes. A full report of the tests giving all details must be made.

3.6.1.10 Induced AC Testing

Before final acceptance of the installation, induced AC Voltage tests must be performed on the pipes near high AC Voltage infrastructure and where crossing above ground and underground AC transmission systems. A full report of these tests must be included in the final testing reports with all details and data taken. The touch potential of any testing over 5 volts must be reported to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Any touch potential over 10 Volts must be mitigated by effective mitigation techniques. Refer to NACE SP0177 and NACE SP21424.

3.6.1.11 Interference Tests

Before final acceptance of the installation, interference tests will be made with respect to any foreign pipes in cooperation with the owner of the foreign pipes. A full report of the tests giving all details must be made. Stray current measurements must be performed at all isolating locations and at locations where the new pipeline crosses foreign metallic pipes; results of stray current measurements must also be submitted for approval. The method of measurements and locations of measurements must be submitted for approval. As a minimum, stray current measurements must be performed at the following locations:

- a. Connection points of new pipeline to existing pipeline.
- b. Crossing points of new pipeline with other existing metallic pipelines.

3.6.1.12 Initial Cathodic Protection System Field Testing

Initial field testing must be completed by the contractor upon completion of construction. Field testing must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative 5 days prior to performing each field test. Field testing must include native and protected potentials, and anode current testing.

The contractor must submit an initial field test report of the cathodic protection system. All structure-to-electrolyte measurements, including

initial potentials, anode outputs, and other required testing must be recorded on applicable forms. Identification of test locations, test station and anode test stations will coordinate with the as-built drawings and be provided on system drawings included in the report. The contractor must locate, correct, and report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager any short circuits encountered during the checkout of the installed CP system.

3.6.1.13 Field Testing

The corrosion [expert](#) must review the contractor's initial field testing report. Approximately four weeks after receipt of the contractor's initial test report, the system will be tested and inspected in the contractor's presence by the corrosion [expert](#). The contractor must correct, at the contractor's expense, materials and installations observed by these tests and inspections to not be in conformance with the plans and specifications. The contractor will pay for all retesting done by the government engineer made necessary by the correction of deficiencies.

3.6.1.14 One-Year-Warranty-Period-Testing

The contractor must inspect, test, and adjust the cathodic protection system quarterly for one year, 4 interim inspections total, to ensure its continued conformance with the criteria outlined below. The performance period for these tests will commence upon the completion of all cathodic protection work, including changes required to correct deficiencies identified during initial testing, and preliminary acceptance of the cathodic protection system by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Copies of the [One Year Warranty Period Cathodic Protection System Field Test Report](#), including field data, and certified by the contractor's corrosion engineer must be submitted to the Contracting Officer or Contracting Officer's Representative, the activity, and the corrosion [expert](#).

3.6.1.15 Final Acceptance Field Testing

Conduct final field testing of the cathodic protection system utilizing the same procedures specified under, "Initial Field Testing of the Galvanic Cathodic Protection Systems". The contractor will inspect, test, and adjust the cathodic protection system after one year of operation to ensure its continued conformance with the criteria outlined below. The performance period for these tests will commence upon preliminary acceptance for the cathodic protection system by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Copies of the [Final Cathodic Protection System Field Test Report](#), certified by the contractor's corrosion engineer must be submitted to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager and the corrosion [expert](#) for approval, and as an attachment to the operation and maintenance manual in accordance with [Section 01 78 23 OPERATION AND MAINTENANCE DATA](#). The corrosion [expert](#) must review the contractor's final field testing report.

3.7 CLOSEOUT ACTIVITIES

3.7.1 Reconditioning of Surfaces

3.7.1.1 Concrete

Concrete must be 3000 psi minimum ultimate 28-day compressive strength with one inch minimum aggregate conforming to Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.7.1.2 Restoration of Sod

Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. In areas where grass cover exists, it is possible that sod can be carefully removed, watered, and stored during construction operations, and replaced after the operations are completed since it is estimated that no section of pipeline must remain uncovered for more than two (2) days. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding. Seeding must be done as directed, in all unsurfaced locations where sod and topsoil could not be preserved and replaced. The use of sod in lieu of seeding will require approval by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.7.1.3 Restoration of Pavement

Repair pavement, sidewalks, curbs, and gutters where existing surfaces are removed or disturbed for construction. Saw cut pavement edges. Graded aggregate base course must have a maximum aggregate size of 1 1/2 inches. Prime base course with liquid asphalt, ASTM D2028/D2028M, Grade RC-70 prior to paving. Match base course thickness to existing but must not be less than 6 inches. Asphalt aggregate size must be 1/2 inch , asphalt cement must conform to ASTM D3381/D3381M, Grade AR-2000 . Match asphalt concrete thickness to existing but must not be less than 2 inches. Repair Portland cement concrete pavement, sidewalks, curbs, and gutters using 3,000 psi concrete conforming to Section 03 30 00 CAST-IN-PLACE CONCRETE. Match existing pavement, sidewalk, curb, and gutter thicknesses.

3.7.1.4 Cleanup

The contractor is responsible for cleanup of the construction site. All paper bags, wire clippings, must be disposed of as directed. Paper bags, wire clippings and other waste will not be put in bell holes or anodes excavation.

3.7.2 Training

3.7.2.1 Instruction to Government Personnel

During the warranty testing or at a time designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager, make available the services of a technician regularly employed or authorized by the manufacturer of the Cathodic Protection System for instructing government personnel in the proper operation, maintenance, safety, and emergency procedures of the Cathodic Protection System. The period of instruction must be not less than four hours and not more than two 8-hour working days. Conduct the training at the jobsite or at another location mutually satisfactory to the government and

the contractor. The field instructions will cover all of the items contained in the operation and maintenance manual.

-- End of Section --

SECTION 26 51 00

INTERIOR LIGHTING

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2023) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2023) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D4674 REV A	(2002; R 2010) Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED

Packages, Arrays and Modules

ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES TM-15	(2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires
ANSI/IES TM-21	(2019) Technical Memorandum: Projecting Long-Term Lumen, Photon, and Radiant Flux Maintenance of LED Light Sources
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps– Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 7	(2011; R 2016; R 2021) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 7 2023; TIA 23-15) National Electrical Code
NFPA 101	(2021; TIA 21-1) Life Safety Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15

Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 94	(2023; Reprint Jan 2024) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 916	(2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment
UL 924	(2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1598	(2021; Reprint Jun 2021) Luminaires
UL 8750	(2015; Reprint Sep 2021) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Cybersecurity requirements are specified in Section 25 05 11. CYBERSECURITY FOR ELECTRONIC SECURITY SYSTEMS (ESS). Commissioning requirements are specified in Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING.

1.3 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings, must be as defined in IEEE 100 and ANSI/IES LS-1.
- b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in ANSI/IES LM-80.
- c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.
- d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.

Submit the following in accordance with Section 01 33 00 SUBMITTAL

PROCEDURES:

SD-02 Shop Drawings

Occupancy/Vacancy Sensor Coverage Layout; G, D0; S

Lighting Control System One-Line Diagram; G, D0

Sequence of Operation for Lighting Control System; G, D0

SD-03 Product Data

Luminaires; G, D0

Luminaire Warranty; G, D0

Lighting Controls Warranty; G, D0

Room Controllers; G, D0

Switches; G, D0

Low Voltage, Multi-Button Wallstations; G, D0

Low Voltage, Scene Wallstations; G, D0

Occupancy/Vacancy Sensors; G, D0

Daylight Sensor; G, D0

Integral Photocell and Motion Sensor; G, D0

Exit Signs; G, D0

Emergency Drivers; G, D0

SD-06 Test Reports

Occupancy/Vacancy Sensor Verification Test; G, D0

Lighting Switch Verification Test; G, D0

Photocell and Motion Sensor Verification Test; G, D0

SD-07 Certificates

LED Driver and Dimming Switch Compatibility Certificate; G, D0

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G, R0

Lighting Control System, Data Package 5; G, R0

Maintenance Staff Training Plan; G, R0

End-User Training Plan; G, R0

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices without flickering and to specified dimming levels.

1.5.2 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.3 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must be one of the following:

- a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.
- b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List for LM-79 testing.
- c. One of the EPA-Recognized Laboratories listed for LM-80 testing.

1.5.4 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design, and workmanship. Products must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated

in this section.

1.5.5.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.5.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

- a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

- (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

- (2) Material warranty must include:

- (a) All LED drivers and integral control equipment.

- (b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

- (c) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) show a color shift greater than 0.003 delta u'v' from the zero hour measurement stated in the **ANSI/IES LM-79** Test Report.

- b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

- c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and assembly.

1.6.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

- a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:
 - (1) Software: Failure of input/output to execute switching or dimming commands.
 - (2) Damage of electronic components due to transient voltage surges.
 - (3) Failure of control devices, including but not limited to occupancy sensors, photosensors, and manual wall station control devices.
- b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.
- c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7 OPERATION AND MAINTENANCE MANUALS

1.7.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system for the building. Include the following:

- a. Manufacturers' operating and maintenance manuals.
- b. Luminaire shop drawings for modified and custom luminaires.
- c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.7.2 Lighting Control System

Provide operation and maintenance manuals for the lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting control system for the building. Include the following:

- a. Lighting control system layout and wiring plan.
- b. Lighting control system one-line diagram.
- c. Product data for all devices, including installation and programming

instructions.

- d. Occupancy/vacancy sensor coverage layout.
- e. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the lighting control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.
- f. Sequence of operation descriptions for each typical room type, including final programming, schedules, and calibration settings.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and NL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the driver and light source provided.

2.2.1 Luminaires

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

- a. Complete system with LED drivers and light sources.
- b. Housings constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.
- c. **ANSI/IES TM-21, ANSI/IES LM-80.** Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.
- d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Recessed 1 by 4, 2 by 4, and 2 by 2	100 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Accent (undercabinet, cove)	45 LPW
Linear, Ambient (indirect wall mount, linear pendent)	100 LPW

Luminaire Style	Minimum Luminaire Efficacy
High Bay, Low Bay, and Industrial Locations	100 LPW
Exterior Wall Sconce	50 LPW

- e. UL listed for dry or damp location typical of interior installations. Any luminaire mounted on the exterior of the building must be UL listed for wet location typical of exterior installations.
- f. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.
- g. Lenses constructed of heat tempered borosilicate glass, UV-resistant acrylic, or silicone. Sandblasting, etching and polishing must be performed as indicated in the luminaire description.
- h. **ANSI/IES TM-15**. Provide exterior building-mounted luminaires that do not exceed the BUG ratings as listed in the luminaire schedule. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, **NEMA SSL 3**. Provide type, delivered lumen output, and wattage as indicated in the luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

- a. **NEMA ANSLG C78.377**. Emit white light and have a nominal CCT of 4000 Kelvin.
- b. Minimum Color Rendering Index (CRI) of 80
- c. Light source color consistency by utilizing a binning tolerance within a 3-step McAdam ellipse.
- d. Color maintenance value of no greater than 0.003 (delta u'v') at 6000 hours as listed in **ANSI/IES LM-79** Test Report.

2.4 LED DRIVERS

NEMA SSL 1, **UL 8750**. Provide LED drivers that are electronic, UL Class 1 or Class 2, constant-current type and that comply with the following requirements:

- a. The combined driver and LED light source system does not exceed the minimum luminaire efficacy values as listed in the luminaire schedule provided.

- b. Operates at a voltage **as indicated** at 60 hertz, with input voltage fluctuations of plus/minus 10 percent.
- c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.
- d. Maximum Total Harmonic Distortion (THD) less than 20 percent at full input power and across specified dimming range.
- e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.
- f. Withstands Category A surges of 2 kV without impairment of performance. Provide surge protection that is integral to the driver.
- g. Integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.
- h. **47 CFR 15**. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
- i. Class A sound rating.
- j. **Directive 2011/65/EU**. Restriction of Hazardous Substances (RoHS) compliant.
- k. Provide dimming capability as indicated in the luminaire schedule on project plans. Dimmable drivers must dim down to 10 percent (**or lower where indicated in the luminaire schedule**). Dimmable drivers must be controlled by a Class 2 low voltage 0-10VDC controller dimming signal protocol unless otherwise specified. LED drivers of the same family/series must track evenly across multiple luminaires at all light levels.

2.5 LIGHTING CONTROLS

Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section **25 05 11**. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Provide lighting control systems that do not switch off battery-operated or emergency backup luminaires or exit signs in path of egress. Provide system with override of lighting control devices controlling luminaires in path of egress with activation of fire alarm system.

2.5.1 System

Provide lighting control system that operates the lighting system as described in the lighting control strategies in the project plans. Submit **Sequence of Operation for Lighting Control System** describing the operation of the proposed lighting control system and devices. Sequence of Operation must provide the strategies identified in the lighting control strategies.

2.5.1.1 Localized Control Systems

Provide room or area-wide lighting control system capable of manual

control, time-based control, and receiving input from photosensors and occupancy/vacancy sensors.

2.5.1.1.1 ROOM CONTROLLERS

Room controllers shall work in conjunction with low voltage, multi-button wallstations, occupancy/vacancy sensors, and receptacle-rated switchpacks, etc. to provide a fully functional lighting control system that meets the operational requirements indicated in the contract documents. Room controllers shall be provided with the necessary features (e.g., number of relays, inputs, outputs, etc.) as required to meet each room's operational requirements. Each room controller relay shall be capable of controlling a combined lighting load of 20A at 120/277 VAC. Room controllers in rooms with sensor-controlled receptacles shall have the capability to interface with receptacle-rated switchpacks in order to provide sensor control of the indicated receptacles. Room controllers shall have an alert mode input capability that allows for the fire alarm system to set all controlled lighting to a full ON condition. Provide low voltage wiring to switchpacks as required. Room controllers and ancillary devices (e.g., wallstations, sensors, etc.) shall be from a single manufacturer. Provide low voltage wiring between room controller and ancillary devices per manufacturer's requirements. Wireless controls are not allowed. Furnish any programming devices required to program or adjust the room controllers. Room controllers shall be furnished with the manufacturer's warranty for a minimum of 5 years.

Mount room controllers above the entrance door of the room being controlled. Provide ceiling access panels where room controllers are installed above inaccessible ceilings (e.g., gypsum board ceilings).

2.5.2 Devices

2.5.2.1 Switches

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. When used for non-digital loads, devices must be rated at 20 Amps inductive load, and be compatible with the lighting control systems.

2.5.2.2 Low Voltage, Multi-Button Wallstations

Low voltage, multi-button wallstations shall provide continuous, flicker-free dimming with 0-10V, 1 percent dimming drivers. Wallstations shall have the buttons as indicated on the drawings. Wallstations shall be 100 percent fully compatible with the dimming drivers. Wallstation buttons shall be engraved or marked with their corresponding descriptions. Wallstations shall be from the same manufacturer as the room controllers.

2.5.2.3 Low Voltage, Scene Wallstations

Provide scene wallstations that are compatible with the other components of the lighting control system and capable of Class 1 or 2 wiring methods in accordance with the NEC and local codes. Provide devices that contain on/off group, preset scene functions, or dim up/dim down interface through front panel. Programming of new scenes or zone assignments must be accomplished by authorized personnel from the space being controlled. Provide labeling for each button, including laminated sheet with scene descriptions to be posted near each scene controller.

2.5.2.4 Occupancy/Vacancy Sensors

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A, NEMA WD 7. Provide occupancy/vacancy sensors with coverage patterns as required to achieve detection of walking motion in corridors and similar spaces and hand motion in offices, classrooms, and similar spaces. Only PIR sensors are allowed due to the security requirements of the facility. No ultrasonic sensors are allowed in the facility. Provide ceiling or wall-mounted occupancy/vacancy sensors that meet the following requirements:

- a. Operating voltage of 12-24 volts.
- b. Time delay of 20 minutes.
- c. Shielded or controlled by internal logic to adjust sensitivity to avoid false triggering due to ambient temperature, air temperature variations or HVAC air movement.
- d. Sensor is equipped to automatically energize the connected load upon loss of normal power when located in a means of egress.
- e. Occupancy and vacancy operation is field-adjustable.
- f. No leakage current to load when in the off mode.
- g. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.

2.5.2.4.1 Passive Infrared Sensors

Provide Passive Infrared Sensors (PIR) sensors that detect occupancy by sensing heat and movement in the area of coverage. Provide sensors are constructed of a housing of high-impact, injection-molded thermoplastic. Provide PIR sensors that are temperature compensated, with a dual element sensor and a multi-element fresnel lens of POLY IR4 material.

2.5.2.5 Daylight Sensor

Provide daylight sensor that measures the natural light contribution in order to automatically adjust the lighting zones within the room controller. The daylight sensor shall be from the same manufacturer as the room controller. The daylight sensor shall be capable of controlling independent daylight zones.

2.5.2.6 Integral Photocell and Motion Sensor

Provide outdoor-rated photocell and motion sensor integral to exterior wall luminaire that meet the following requirements:

- a. Photocell must detect changes in ambient lighting level and motion sensor must detect walking motion to enable dusk-to-dawn operation at 50% light level with raising to 100% light level upon additional detection of walking motion.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

2.6.1 Exit Signs

UL 924, NFPA 101. Exit signs shall use no more than 2 watts. Provide LED Exit Signs that meet the following criteria:

- a. Housing constructed of painted, die-cast aluminum. Provide 5-year warranty for exit signs.
- b. Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver..
- c. Configured for universal mounting.
- d. 6 inch high, 3/4 inch stroke red lettering on face of sign with chevrons on either side of lettering to indicate direction.
- e. Single or double face as indicated in project plans and luminaire schedule.

2.6.2 LED Emergency Drivers

UL 924, NFPA 101. Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver. Integral nickel-cadmium battery is required to supply a minimum of 90 minutes of emergency power at watts indicated on the Luminaire Schedule, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of five years.

2.6.3 Self-Diagnostic Circuitry for LED Drivers

UL 924, NFPA 101. Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.7 LUMINAIRE MOUNTING ACCESSORIES

2.7.1 Suspended Luminaires

- a. Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers.
- b. Hangers must allow luminaires to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Provide with swivel hangers to ensure a plumb installation for rigid stem

pendents. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.

- c. Single-unit suspended luminaires must have cable **or** twin-stem hangers. Multiple-unit or continuous row luminaires with a separate power supply cord must have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.
- d. Provide all linear pendent and surface mounted luminaires with two supports per four-foot section or three per eight-foot section unless otherwise recommended by manufacturer.
- e. Provide rods in minimum **0.18 inch** diameter.

2.7.2 Recess and Surface Mounted Luminaires

Provide access to light source and LED driver from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications. Luminaires recessed in ceilings which have a fire resistive rating of one hour or more must be enclosed in a box which has a fire resistive rating equal to that of the ceiling. For surface mounted luminaires with brackets, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the luminaire rigidly in design position. Flanged part of luminaire stud must be of broad base type, secured to outlet box at not fewer than three points.

2.7.3 Luminaire Support Hardware

2.7.3.1 Wire

ASTM A641/A641M. Galvanized, soft tempered steel, minimum **0.11 inches** in diameter, or galvanized, braided steel, minimum **0.08 inches** in diameter.

2.7.3.2 Wire for Humid Spaces

ASTM A580/A580M. Composition 302 or 304, annealed stainless steel, minimum **0.11 inches** in diameter.

ASTM B164. UNS N04400, annealed nickel-copper alloy, minimum **0.11 inches** in diameter.

2.7.3.3 Threaded Rods

Threaded steel rods, **3/16 inch** diameter, zinc or cadmium coated.

2.7.3.4 Straps

Galvanized steel, **one by 3/16 inch**, conforming to **ASTM A653/A653M**, with a light commercial zinc coating or **ASTM A1008/A1008M** with an electrodeposited zinc coating conforming to **ASTM B633**, Type RS.

2.8 EQUIPMENT IDENTIFICATION

2.8.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a

conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.8.2 Labels

UL 1598. All luminaires must be clearly marked for operation of specific light sources and LED drivers. The labels must be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Note the following light source characteristics in the format "Use Only ____":

- a. Correlated Color Temperature (CCT) and Color Rendering Index (CRI) for all luminaires.
- b. Driver and dimming protocol.

All markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.9 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature (CCT), color rendering index (CRI), and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Luminaire catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a luminaire may be installed. Provide wires, straps, or rods for luminaire support in this section. Install luminaires with vent holes free of air blocking obstacles.

3.1.2.1 Suspended Luminaires

Measure mounting heights from the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain architect approval of the exact mounting height on the job before commencing installation and, where applicable, after

coordinating with the type, style, and pattern of the ceiling being installed. Support suspended luminaires from structural framework of ceiling or from inserts cast into slab.

- a. Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level.
- b. Locate so that there are no obstructions within the 45 degree range in all directions.
- c. The stem, canopy and luminaire must be capable of 45 degree swing.
- d. Rigid pendent stem, aircraft cable, rods, or chains **4 feet** or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation.
- e. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces.
- f. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints.
- g. Support steel luminaires to prevent "oil-canning" effects.
- h. Match supporting pendants with supported luminaire. Aircraft cable must be stainless steel.
- i. Match finish of canopies to match the ceiling, and provide low profile canopies unless otherwise shown.
- j. Maximum distance between suspension points must be **10 feet** or as recommended by the manufacturer, whichever is less.

3.1.2.2 Recessed and Semi-Recessed Luminaires

- a. Support recessed and semi-recessed luminaires independently from the building structure by a minimum of two wires, straps or rods per luminaire and located near opposite corners of the luminaire. Secure horizontal movement with clips provided by manufacturer. Ceiling grid clips are not allowed as an alternative to independently supported luminaires.
- b. Support round luminaires or luminaires smaller in size than the ceiling grid independently from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around.
- c. Do not support luminaires by acoustical tile ceiling panels.
- d. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two **3/4 inch** metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire.
- e. Luminaires installed in suspended ceilings must also comply with the requirements of Section **09 51 00** ACOUSTICAL CEILINGS.

- f. Adjust aperture rings on all applicable ceiling recessed luminaires to accommodate various ceiling material thickness. Coordinate cut-out size in ceiling to ensure aperture covers cut-out entirely. Install aperture rings such that the bottom of the ring is flush with finished ceiling or not more than 1/16 inch above. Do not install luminaires such that the aperture ring extends below the finished ceiling surface.
- g. For luminaire recessed in plaster ceilings, provide plaster frames for setting. Install setting such that the bottom of the frame is flush with finished ceiling. Support luminaires with plaster frames utilizing yokes or leveling lugs. Do not mount luminaires or support elements to ducts or pipes. Yokes must support a luminaire by no fewer than two bolts each.

3.1.2.3 Field Applied Painting

Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.3 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.4 Exit Signs

NFPA 101. Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.1.5 Lighting Controls

Refer to Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS for additional lighting control installation requirements.

3.1.5.1 Wallstations

Submit labeling templates for all scene wallstations, ganged faceplates and other manual control cover plates. Label each scene control button with approved scene description.

3.1.5.2 Occupancy/Vacancy Sensors

- a. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways.
- b. Locate ceiling-mounted sensors no closer than 6 feet from the nearest HVAC supply or return diffuser.
- c. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations.

3.1.5.3 Daylight Sensor

Locate sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for the indicated light level set point

measured at the work plane for that particular area.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

3.2.1.1 Lighting Control Verification Tests

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed **before** commissioning.

- a. Verify occupancy/vacancy sensors operate as described in sequence of operations. Provide testing of sensor coverage, sensitivity, and time-out settings in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit **occupancy/vacancy sensor verification test**.
- b. **Verify low voltage, multi-button wallstations, scene wallstations, and other lighting control switches operate as described in sequence of operations. Submit lighting switch verification test.**
- c. **Verify integral photocell and motion sensors operate as described in sequence of operations. Provide testing of sensor coverage, aiming, and calibration in all spaces where sensors are placed. Submit photocell and motion sensor verification test.**

3.2.1.2 Emergency Lighting Test

Interrupt power supply to demonstrate proper operation of emergency lighting. If adjustments are made to the lighting system, re-test system to show compliance with standards.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Commissioning

NFPA 101. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 20 TOTAL BUILDING COMMISSIONING. Factory Trained Field Service Technician is responsible for calibration and programming sequences for input devices and systems in accordance with the requirements described in the sequence of operation.

3.3.2 Training

3.3.2.1 Maintenance Staff Training

Submit a **Maintenance Staff Training Plan** at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrates full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.2.2 End-User Training

Submit an [End-User Training Plan](#) at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide users with a list of control devices located within user-occupied spaces, such as [photocells](#) and occupancy and vacancy sensors, including information on the proper operation and schedule for each device. Provide demonstration for each type of interface. Provide users with the building schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

Provide laminated instructions to the user at each scene wallstation. Provide only instructions relevant to the functionality of the specific scene wallstation. Provide a description of each labeled scene control button. If the room utilizes occupancy/vacancy sensors or [photocells](#), include a description of this functionality on the instruction sheet.

-- End of Section --

SECTION 27 05 13.43

TELEVISION DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2023) National Electrical Safety Code

IEEE C62.41.1 (2002; R 2008) Guide on the Surges
Environment in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on
Characterization of Surges in Low-Voltage
(1000 V and Less) AC Power Circuits

NATIONAL CABLE AND TELECOMMUNICATIONS ASSOCIATION (NCTA)

NCTA RP (1989) NCTA Recommended Practices for
Measurements on Cable Television Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National
Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 76.605 Technical Standards

UNDERWRITERS LABORATORIES (UL)

UL 969 (2017; Reprint Mar 2018) UL Standard for
Safety Marking and Labeling Systems

UL 1581 (2001; Reprint Jan 2023) UL Standard for
Safety Reference Standard for Electrical
Wires, Cables, and Flexible Cords

UL 1666 (2007; Reprint Sep 2021) UL Standard for
Safety Test for Flame Propagation Height
of Electrical and Optical-Fiber Cables
Installed Vertically in Shafts

1.2 DEFINITIONS

1.2.1 Television Distribution System

The television distribution system system, commonly referred to as cable

television, is a network of cables, headend, electronic and passive components that process and amplify television (TV) signals for distribution of adequate signals to each receiver from the headend equipment to the individual television outlets and provides distortion-free signal to TV sets by isolating each receiver from the system and providing the proper amount of signal to each set.

1.2.2 Headend

The connection point between television distribution system equipment and equipment provided by the local television service provider.

1.2.3 Distribution System

Distribution system transports and delivers adequate signals to each receiver. Provides distortion-free signal to **display monitors** by isolating each receiver from the system and by providing proper amount of signal to each set.

1.2.4 Cable

Trunk and feeder cables are low-loss cables used to transport the desired signal from the headend equipment to the telecommunications room in the area to be served. These cables are used to transport signal from the headend equipment to the telecommunications room. Drop cables are used to transport the desired signal used from the telecommunications room to the wall outlet.

1.3 SYSTEM DESCRIPTION

1.3.1 Distribution System

Distribution system shall be star topology with each outlet connected to a telecommunications room with a feeder cable or a drop cable and each telecommunications room connected to the headend equipment with a coaxial trunk cable.

1.3.2 Cable

Provide trunk cables to transport the desired signal from the headend equipment to the telecommunications room in the area to be served. **Where indicated, provide feeder cables to transport the desired signal from the telecommunications room on each floor to splitters. Provide drop cables to transport the desired signal from the telecommunications room on each floor (or splitters where indicated) to the outlet.**

1.3.3 System Components

System shall provide high quality TV signals to all outlets. Provide any combination of items specified herein to achieve required performance, subject to approvals, limitations, acceptance test, and other requirements specified herein. System shall include amplifiers, splitters, combiners, line taps, cables, outlets, tilt compensators and all other parts, components, and equipment necessary to provide a complete and usable system.

1.3.3.1 System Bandwidth

- a. Downstream: 50-1000 MHz minimum.

- b. Upstream 5-40 MHz minimum.

1.3.4 System Performance

System shall be in compliance with 47 CFR 76.605.

1.3.4.1 Receiver Termination Signal Level

Each termination for a TV receiver must have a minimum signal level of 0 decibel millivolts (dBmV) (1000 microvolts) at 55 MHz and of 0 dBmV (1000 microvolts) at 1000 MHz and a maximum signal of 15 dBmV or a level not to overload the receiver for the entire system bandwidth.

1.3.4.2 Distribution System

- a. Modulation distortion at power frequencies: 4 percent or less hum distortion;
- b. Composite third order distortion for:
 - (1) CW carriers: 53 dB.
 - (2) Modulated carriers: 59 dB.
- c. Subscriber terminal isolation: 18 dB or greater.
- d. Carrier to second order beat ratio: 60 dB.
- e. Amplitude characteristic: within a range of plus or minus 2 decibels from 0.75 MHz to 5.0 MHz above the lower boundary frequency of the cable television channel, referenced to the average of the highest and lowest amplitudes within these frequency boundaries.
- f. Visual, aural carrier level, 24-hour variation: 47 CFR 76.605, subpart (a), rules (4), (5), and (6).
- g. Frequency determination: 47 CFR 76.605, subpart (a), rules (1), (2), and (3).

1.3.4.3 System Tolerance

The system must not show a serious loss of carrier to noise when the system levels are lowered 3 dB below normal or a significant distortion when the levels are increased 3 dB above normal, as observed on a TV set located at the far end extremities of the system.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Television Distribution System Wiring Diagrams And Installation Details; G, R0

Television Distribution System Components; G, R0

SD-03 Product Data

Attenuators; G, R0

Amplifiers, including Headend, Trunk, Bridging, and Distribution; G, R0

Cables, including Trunk, Feeder, and Drop; G, R0

Terminators; G, R0

Splitters/Combiners; G, R0

Coaxial Outlets; G, R0

Coaxial Connectors; G, R0

Submittals for each manufactured item must be the current manufacturer's descriptive literature of catalog products, equipment drawings, diagrams, performance and characteristics curves, and catalog cuts.

SD-05 Design Data

Television Distribution System Loss Calculations; G, D0

SD-06 Test Reports

Operational Test Plan; G, R0

Operational Test Procedures; G, R0

System Pretest; G, R0

Acceptance Tests; G, R0

SD-08 Manufacturer's Instructions

Connector Installation; G, R0

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, R0

Submit Data Package 5 for each component in accordance with requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 QUALITY ASSURANCE

1.5.1 Wiring Diagrams and Installation Details

Illustrate how each item of equipment functions in the system and include an overall system schematic indicating the relationship of television distribution system units on one diagram. Drawings must include wiring diagrams and installation details of equipment indicating proposed locations, layout and arrangements, and other items that must be shown to

ensure coordinated installation.

1.5.2 Television Distribution System Loss Calculations

Calculations must verify that the system does not exceed the loss values specified in dBmV at the input of all active devices and the receiver terminations. Provide a drawing displaying all distribution network calculations. The drawing should accurately show taps, splitters, outlets, and the type and length of all trunk, feeder, and drop cables. The drawing must show how many taps, splitters, or outlets are served by each tap or splitter.

1.5.3 Operational Test Plan

Test plan must define tests required to ensure that the system meets technical, operational, and performance specifications. Test plan must be based on NCTA RP and be in accordance with FCC proof of performance requirements. Test plan must include plan for testing for signal leakage. Provide test requirements and guidelines.

1.5.4 Operational Test Procedures

Use test plan and design documents to develop test procedures. Procedures must consist of detailed instructions for a test setup, execution, and evaluation of test results.

1.5.5 Connector Installation

Provide manufacturer's instructions for installing connectors.

PART 2 PRODUCTS

2.1 ELECTRONIC EQUIPMENT

Electronic components of similar type must be produced and designed by the same manufacturer as major components of the equipment and must have the manufacturer's name and model permanently attached. Equipment must function properly as a complete integrated system. Equipment must be shielded. The system must be designed to operate within 5 to 1000 MHz bandwidth using 1000 MHz passive devices and a minimum of 1000 MHz active devices.

2.2 HEADEND EQUIPMENT

2.2.1 Headend Amplifiers

Provide broadband distribution amplifiers. Amplifiers must amplify broadband signals from 40 to 1000 MHz and provide an amplified return path for signals from 5 to 40 MHz for 75 ohms impedance. Amplifiers must be bidirectional with variable slope and gain control.

2.2.2 Attenuators

Provide attenuators to equalize signal levels, when required. Variable attenuators are not permitted.

2.2.3 Power Supplies

Power supplies must contain a current limiter circuit to protect against

short circuits on the radio frequency (RF) line. Provide overvoltage protection to protect solid state equipment from line surges and induced voltages, in accordance with IEEE C62.41.1 and IEEE C62.41.2.

2.3 DISTRIBUTION EQUIPMENT

2.3.1 Distribution Amplifiers

Distribution amplifiers shall be equipped for 75 ohms input and output impedance. Electronic equipment exposed to weather shall be equipped with weatherproof housings. Amplifiers shall be bidirectional with variable slope and gain control and shall amplify broadband signals from 50 to 1000 MHz and provide an amplified return path for signals from 5 to 40 MHz for 75 ohms impedance.

2.3.1.1 Bridging Amplifiers

Bridging amplifiers shall be used to connect feeder cables to trunk cables.

2.3.2 Cables and Associated Hardware

Cabling shall be UL listed for the application and shall comply with NFPA 70. Provide a labeling system for cabling as required by UL 969. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.2.1 Trunk Cable

UL 1666. Provide trunk cable with an NFPA 70 rating of CATVR.

a. Provide RG-11 coaxial cable with the following characteristics:

- (1) 14 AWG copper-clad steel center conductor.
- (2) Gas injected foam polyethylene dielectric with nominal 0.28 inches outer diameter.
- (3) Bonded foil inner-shield and 60 percent aluminum braid.
- (4) 75 ohms impedance.
- (5) 82 to 85 percent nominal velocity of propagation.
- (6) Black PVC jacket
- (7) Maximum attenuation characteristics:

MHz	DB/100 ft
5	0.38
55	0.96
300	2.25
350	2.42

MHz	DB/100 ft
450	2.86
500	2.90
600	3.18
750	3.65
1000	4.35

2.3.2.2 Feeder Cable

UL 1581, provide RG-11 coaxial trunk cable with an NFPA 70 rating of CATV and the following characteristics:

- a. 14 AWG copper-clad steel center conductor.
- b. Gas injected foam polyethylene dielectric with .28 inches nominal outer diameter.
- c. Bonded foil inner-shield and a minimum of 60 percent aluminum braid.
- d. 75 ohms impedance.
- e. 81 to 84 percent nominal velocity of propagation.
- f. Black PVC jacket.
- g. Maximum attenuation characteristics:

CATV	
MHz	DB/100 ft
50	.95
100	1.3
200	1.9
400	2.7
700	3.9
1000	4.8

2.3.2.3 Drop Cable

UL 1581. Provide RG 6 coaxial cable with an NFPA 70 rating of CATV and with the following characteristics:

- a. No. 18 AWG copper-clad steel center conductor.

- b. Bonded foil inner-shield and 90 percent aluminum braid.
- c. Characteristic impedance of 75 ohms.
- d. Gas injected foam polyethylene dielectric
- e. Nominal capacitance, conductor to shield, of 16.2 pf per 100 ft .
- f. Maximum operating voltage of 350 V RMS.
- g. Maximum attenuation:

CATV	
MHz	DB/100 ft
10	0.81
50	1.46
100	2.05
200	2.83
400	4.0
500	4.53
700	6.0
1000	7.3

- h. Black polyvinyl chloride (PVC) jacket.
- i. 100 percent sweep testing from 5 MHz to a minimum of 1000 MHz.

2.3.3 Terminators

Coaxial terminators shall be rated for 75 ohms and 1/4 watt.

2.3.4 Splitters/Combiners

Use splitters/combiners with characteristics equal to or exceeding the characteristics listed in this paragraph over the entire operating band. All unused outlets must be terminated with 75-ohm terminators.

- a. Peak to Valley: Not to exceed 1 dB across bandwidth of device.
- b. Return loss: 18 dB minimum.
- c. Bandwidth: 5-1000 Mh

2.3.5 Coaxial Outlets

Provide flush mounted, 75-ohm, F-type connector outlets rated from 5 to 1000 MHz in standard electrical outlet boxes. Provide modular faceplates

for mounting of CATV Outlets. Faceplate: include designation labels and label covers for circuit identification. Faceplate color: Color shall comply with Division 09 series color schedule.

2.3.6 Coaxial Connectors

Provide one piece connectors. Drop cable connectors shall be feed thru type.

2.4 GROUNDING AND BONDING

Provide ground rods and connections in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.1 Grounding Busbars

Provide grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.5 BACKBOARDS

Provide void-free, fire rated interior grade plywood, 3/4 inch thick, as indicated. Backboards shall not be painted.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Distribution System

Distribution system shall conform to requirements specified herein. Installation shall be in accordance with IEEE C2 and NFPA 70.

3.1.1.1 Raceway

Provide cable installed in conduit in compliance with NFPA 70. Raceway shall comply with Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM. Provide 4 inch, minimum, PVC from interior headend location to exterior television service provider connection location. Coordinate location and requirements with the local cable television service provider.

3.1.1.2 Grounding System

Provide the grounding block at the main television distribution backboard. Ground this device according to the requirements of IEEE C2 and NFPA 70.

3.1.1.3 Trunk, Feeder, and Drop Cable

Provide cable to grounding blocks, to line taps, and to outlets.

3.1.1.4 Splitters

Install in accordance with manufacturer's written instructions.

3.2 FIELD QUALITY CONTROL

3.2.1 System Pretest

Upon completing installation of the television distribution system, the

Contractor shall perform complete pretesting. During the system pretest, Contractor, utilizing the approved spectrum analyzer or signal level meter, shall verify that the system is fully operational and meets all the system performance requirements of the specification. Contractor shall test the signal loss in dBmV at 55 and 1000 MHz. The signal levels shall be 0 dBmV (1000 microvolts), minimum. The signal shall not exceed 15 dBmV over the entire system bandwidth. Any deficiencies found shall be corrected and revalidated by follow up testing. Contractor shall measure and record the video and audio carrier levels at each of the frequency levels specified at each of the following points in the system:

- a. At each outlet.

3.2.2 Acceptance Tests

Contractor shall notify the Contracting Officer of system readiness 10 days prior to the date of acceptance testing. Contractor shall also coordinate with the local television service provider and allow them to attend witness tests. The television distribution system shall be tested in accordance with the approved test plan in the presence of the Contracting Officer's representative to certify acceptable performance. System test shall verify that the total system meets all the requirements of the specification and complies with the specified standards. Contractor shall verify that no signal leakage exists in conformance with NCTA RP and 47 CFR 76.605. System leakage shall also be tested at the headend location with signal applied to system. Deficiencies revealed by the testing shall be corrected and revalidated by follow-up testing. Contractor shall conduct testing at each of the following points in the system:

- a. At each outlet.

3.3 OPERATION AND MAINTENANCE MANUALS

Submit commercial, off-the-shelf manuals for operation, installation, configuration, and maintenance of products provided as a part of the cable television premises distribution system.

-- End of Section --

SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D709 (2017) Standard Specification for
Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and
Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative
Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596 (2021) Indoor Optical Fiber Cables

ICEA S-90-661 (2021) Category 3 and 5E Individually
Unshielded Twisted Pairs, Indoor Cables
(With or Without an Overall Shield) for
Use in General Purpose and LAN
Communications Wiring Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568 (2006) Standard for Installing Building
Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66 (2019) Performance Standard for Category 6
and Category 7 100 Ohm Shielded and
Unshielded Twisted Pairs

NEMA VE 2 (2018; ERTA 1-2 2018) Cable Tray
Installation Guidelines

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National
Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568.0	(2020e) Generic Telecommunications Cabling for Customer Premises
TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-1152	(2016; R 2021) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA/EIA-604-10	(2002a) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-580-01	(2016; with Change 1, 2016) TELECOMMUNICATIONS INTERIOR INFRASTRUCTURE PLANNING AND DESIGN

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations

UL 444	(2017; Reprint Jun 2021) UL Standard for Safety Communications Cables
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2008; Reprint Apr 2021) UL Standard for Safety Office Furnishings
UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Oct 2019) UL Standard for Safety Communication Circuit Accessories
UL 2416	(2020) UL Standard for Audio/Video, Information and Communication Technology Equipment Cabinet, Enclosure, and Rack Systems

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Drawings; G, R0

Telecommunications Space Drawings; G, R0

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications Cabling (backbone and horizontal); G, R0

Pass-Through Faceplate; G, D0

HDBaset Extender Distributor; G, D0

HDBaseT Receiver; G, D0

Patch Panels; G, R0

Telecommunications Outlet/Connector Assemblies; G, R0

Equipment Support Frame; G, R0

Connector Blocks; G, R0

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications Cabling Testing; G, R0

SD-07 Certificates

Telecommunications Contractor Qualifications; G, R0

Key Personnel Qualifications; G, R0

Manufacturer Qualifications; G, R0

Test Plan; G, R0

SD-09 Manufacturer's Field Reports

Factory Reel Tests; G, R0

SD-10 Operation and Maintenance Data

Telecommunications Cabling and Pathway System Data Package 5; G, R0

SD-11 Closeout Submittals

Record Documentation; G, R0

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01 33 00 SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide registered communications distribution designer (RCDD) approved drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, and FD's to the telecommunications work area outlets. The following drawings shall be provided as a minimum:

- a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.
- b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID'S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.
- c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of

Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

All supervisors assigned to the installation of this system or any of its components shall have a minimum Technician certification from BICSI and installers assigned to the installation of this system or any of its components shall have a minimum Level 1 installer certification from BICSI. All supervisors and installers shall also have factory certification from each equipment manufacturer that they are qualified to install and test. The Contractor shall submit certifications to the Contracting Officer, who will in turn provide the NEC's Business and Operations Branch (BOB) with documentation that all installers are BICSI

and factory certified to install and test the intended products.

Key personnel shall have a minimum of three (3) years' experience in the application, installation and testing of the specified systems and equipment to be installed. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568.1, TIA-568.2 and TIA-568.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials,

installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later

than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format and on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Provide the following T5 drawing documentation as a minimum:

- a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.
- b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.1.1 Pass-Through Faceplate

Provide pass-through faceplate with flexible rubber material for 1-gang box sized for passing HDMI and other audio-visual cables.

2.1.2 HDBaseT Extender Distributor

Provide long-reach 1:2 HDBaseT extender distributor that distributes one HDMI signal to two long-reach HDBaseT extension outputs with up to 4K resolution and additional HDMI LOOP output for connecting a local monitor or an additional unit in a daisy chain. Distributor shall provide HDCP 2.2 compliant signal, supporting Deep Color, x.v.Color™, Lip Sync, 7.1 PCM, Dolby TrueHD, DTS-HD, 2K, 4K, and 3D as specified in HDMI 2.0. EDID and CEC (OUT 1 only) signals are passed through from the source to the display. Provide status indicators for HDMI and HDBaseT input/output connected signals and power for ease of maintenance and troubleshooting.

Provide mounting bracket for mounting in lectern.

2.1.3 HDBaseT Receiver

Provide long-reach HDBaseT receiver for 4K60Hz (4:2:0) HDMI over twisted pair. Receiver shall extend video signals to up to 40m (130ft) over CAT copper cables at up to 4K@60Hz (4:2:0) 24bpp video resolution and provides even further reach for lower HD video resolutions. Receiver shall support HDCP 2.2 compliant signal, supporting deep color, x.v.Color™, lip sync, HDMI uncompressed audio channels, Dolby TrueHD, DTS-HD, 2K, 4K, and 3D as specified in HDMI 2.0. Provide status indicators for HDMI and HDBaseT ports for ease of maintenance and troubleshooting.

Provide mounting bracket for wall-mounting behind display monitor.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568.0, TIA-568.1, TIA-568.2, TIA-568.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Backbone Cabling

2.3.1.1 Backbone Copper

Copper backbone cable shall be solid conductor, 24 AWG, 100 ohm, Category 3, UTP, in accordance with ICEA S-90-661, TIA-568.1, TIA-568.2 and UL 444, formed into 25 pair binder groups covered with a gray thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular length marking intervals in accordance with ICEA S-90-661 . Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG)communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.

2.3.1.2 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.

Provide the number of strands indicated of single-mode(OS1), tight buffered fiber optic cable or tight buffered fiber optic multimode, 50/125-um diameter laser optimized (OM3) cable as indicated.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

Provide plenum (OFNP) riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568.1.

2.3.2.1 Horizontal Copper

Provide horizontal copper cable, F/UTP, 100 ohm in accordance with TIA-568.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661. Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a green thermoplastic jacket and a foil shield for unclassified networks. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.3.2.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596 and TIA-568.3. Cable shall be tight buffered, multimode, 50/125-um diameter laser optimized, OM3. Cable shall be imprinted with manufacturer, flammability rating and fiber count at regular intervals not to exceed 40 inches.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs be UL listed and labeled for wet locations in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding as indicated on the drawings.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment rooms to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

2.4.1 Backboards

Install 4'x8', type A-C plywood backboards using galvanized screws covering no less than 2 walls of each tr mounted at 6" aff to ceiling with the "A" side facing out and the manufacturer's fire-retardant stamp visible. Plywood backboards shall not be painted. Each sheet shall be approved and initialed by a NEC representative prior to installation.

2.4.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E, UL 50, and UL 2416.

Provide cabinets, freestanding (42U) or wall-mounted (21U) as indicated. All racks shall be 600mm (23.62") W x 1100mm (43.31") D. Cabinets shall be 16 gauge steel, minimum, treated to resist corrosion. The frame shall include depth markings for ease of EIA rail alignment. Freestanding cabinet frames shall support 4000 lbs. (1361kg) static weight load, 2500 lbs. (1334kg) dynamic (non- transit) weight load, and shall be equipped with leveling feet.

Cabinets shall have two (2) pair of 19" Mounting Rails. The mounting rails shall support the ECIA EIA/ECA 310-E standard hole-mounting pattern, shall be factory-installed in the frame and be individually and infinitely depth-adjustable within the useable space to allow for flexibility of mounting depth. Rails shall be constructed of 12-gauge sheet steel, powder-coat black, with color-contrasting full-height RU position labels on both sides of each rail. Mounting rails shall be capable of accepting tool-less cable management accessories.

Cabinet doors shall be tool-less removable, and field reversible with 3 hinges per door for added rigidity. Doors shall have front and rear combination lock handles with one (1) perforated locking front door and two (2) perforated split locking rear doors.

Cabinet shall be equipped with four (4) (2 per side) lockable split side panels. Split locking side panels shall be made of 16 gauge sheet metal and finished in powder-coat black. Panels shall be externally removable and come standard with locks. Side panels shall be cable pass-through side panels with brush strips shall be available fitted with brush kits. There shall be a tool-less removable type top panel that includes provisions for front and rear cable entrance. Panel shall be made of 16 gauge sheet metal and finished in powder-coat black. The top cover shall include an integrated hole pattern for easy installation of top panel mount accessories (cable management, ladder/cable tray support brackets, etc.), and (1) cutout for top panel fan module and a minimum of eight (8) cable pass-through brush kits for the top panel.

Cabinet shall be accessoried with manufacturer approved products. Provide cabinet with grounding bar, 550 CFM fan with filter and a surge protected power strip with 6 duplex 20 amp receptacles. Fan shall be 110V with NEMA

5-15P plug connection on an attached 6 foot cord. Fan shall be installed in rack top panel capable of 300CFM air circulation. Horizontal cable management shall be single-sided with cover 2U x 4" deep for front-side of rack and single-sided with cover 2U x 6" deep for rear horizontal cable management. Cabinet shall contain two (2) full height PDU/cable management brackets. All PDU/Cable Management Brackets shall be depth-adjustable within the frame and include integrated cable management features to accept tool-less cable management accessories.

Cabinet shall be warranted against defects in materials and workmanship for two (2) years from date of shipment.

2.4.3 Connector Blocks

Provide insulation displacement connector (IDC) Type 110 for Category 6 systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

2.4.4 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment racks cabinets and telecommunications backboards. Cable guides of ring or bracket type devices mounted on rackcabinet panelsbackboard for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, and or nuts and lockwashers.

2.4.5 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568.3. Patch cords shall meet minimum performance requirements specified in TIA-568.1, TIA-568.2 and TIA-568.3 for cables, cable length and hardware specified. Provide one patch cable per port, evenly distributed between 7-foot, 13-foot, and 20-foot cables plus 25 percent spare. Quantity requirement applies to both copper and fiber patch panels. Fiber patch cables will have a standard connector on equipment end, and keyed on the wall plate side according to the color indicated on the drawings.

2.4.5.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568.1 and TIA-568.2. Panels shall be third party verified and shall comply with EIA/TIA Category 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be cabinetrackwall mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment cabinet rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.5.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 18 gauge steel or 11 gauge aluminum

minimum and shall be cabinet, rack or wall mounted and compatible with a ECIA EIA/ECA 310-E 19 inches equipment rack. Each panel shall provide 12 single-mode adapters as duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, alignment sleeves. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

2.4.6 Optical Fiber Distribution Panel

Cabinet, Rack, or Wall mounted optical fiber distribution panel (OFDP) shall be constructed in accordance with ECIA EIA/ECA 310-E utilizing 18 gauge steel or 11 gauge aluminum minimum. Panel shall be divided into two sections, distribution and user. Distribution section shall have strain relief, routing guides, splice tray and shall be lockable, user section shall have a cover for patch cord protection. Each panel shall provide 12 single-mode pigtailed and adapters. Provide adapters as duplex LC with zirconia ceramic alignment sleeves. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 Outlet/Connector Copper

Outlet/connectors shall comply with FCC Part 68, TIA-568.1, and TIA-568.2. UTP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for T568A and T568B wiring. Each outlet/connector shall be wired T568A. UTP outlet/connectors shall comply with TIA-568.2 for mating cycles. Provide a green outlet jack for unclassified network outlets.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

2.5.3 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, ferrule, epoxyless crimp style compatible with 8/125 single-mode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1310 and 1550 nm with less than a 0.2 dB change after 500 mating cycles. Optical fiber connectors shall be keyed and colored as indicated on the drawings.

2.5.4 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568.1, TIA-568.2, ; design constructed of high impact thermoplastic material to match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide labeling in accordance with the

paragraph LABELING in this section.

2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with [UL 467](#), [TIA-607](#), and [NFPA 70](#). Components shall be identified as required by [TIA-606](#). Provide ground rods, bonding conductors, and grounding busbars as specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM.

2.7 FIRESTOPPING MATERIAL

Provide as specified in Section [07 84 00](#) FIRESTOPPING.

2.8 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.9 FIELD FABRICATED NAMEPLATES

[ASTM D709](#). Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, [0.125 inches](#) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be [one by 2.5 inches](#). Lettering shall be a minimum of [0.25 inches](#) high normal block style.

2.10 TESTS, INSPECTIONS, AND VERIFICATIONS

2.10.1 [Factory Reel Tests](#)

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with [TIA-568.1](#), [TIA-568.2](#), [TIA-568.3](#), [TIA-526-7](#) for single mode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with [UFC 3-580-01](#), [NECA/BICSI 568](#), [TIA-568.1](#), [TIA-568.2](#), [TIA-568.3](#), [TIA-569](#), [NFPA 70](#), and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install UTP, and optical fiber telecommunications cabling system as detailed in TIA-568.1, TIA-568.2, TIA-568.3. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Backbone Cable

- a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in indicated pathways, between the campus distributor, located in the telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.
- b. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members exposed for approximately 10 inches. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.2 Horizontal Cabling

Install horizontal cabling as indicated on drawings. Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in its natural lay (not a service loop) on each end of the cable, 10 feet in the telecommunications room, and 12 inches in the cable tray.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.4 Cable Tray Installation

Install cable tray as specified in NEMA VE 2 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.5 Work Area Outlets

3.1.5.1 Terminations

Terminate UTP cable in accordance with TIA-568.1, TIA-568.2 and wiring configuration as specified.

3.1.5.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.5.3 Cables

Do not coil slack for cables inside of outlet boxes. Ensure all cable slack is in its natural lay in the cable tray. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.5.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.6 Telecommunications Space Termination

Install termination hardware required for Category 6 and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.6.1 Connector Blocks

Connector blocks shall be wall mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.6.2 Patch Panels

Patch panels shall be mounted in equipment cabinets or racks with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

- a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel with cable ties as recommended by the manufacturer to prevent movement of the cable.
- b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 20 feet in length. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.6.3 Equipment Support Frames

Install in accordance with TIA-569:

3.1.7 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.8 Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using laser printer .

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.1 Backboards

Backboards must be fire retardant treated, but must NOT be painted. Label and fire rating stamp must be visible.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568.1, TIA-568.2, TIA-568.3. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568.1, TIA-568.2, TIA-568.3, . Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568.3 and TIA-526-7 using Method A, Optical Power Meter and Light Source for single-mode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Perform testing for each outlet as follows:

- a. Perform Category 6 link tests in accordance with TIA-568.1 and TIA-568.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.
- b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568.3.

3.5.1.4 Final Verification Tests

Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

- a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.
- b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 28 08 10

ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING

PART 1 GENERAL

1.1 SUMMARY

This specification defines the process and procedures for initial acceptance testing of electronic security systems (ESS) to include intrusion detection, access control and video as well as associated power and communications. Requirements to plan, conduct, and document all testing activities are covered along with the Government responsibility to witness testing and review and approve submittals. During the course of the acceptance test, demonstrate that, without exception, the completed and integrated ESS complies with the contract requirements.

1.2 DEFINITIONS

The Government Representative is a qualified individual given specific authority to witness system acceptance testing and evaluate the results.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-05 Design Data

Test Plan; G, R0

SD-06 Test Reports

Final Test Report; G, R0

Pre-Acceptance Test Certification; G, R0

SD-07 Certificates

Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 General

The Test Director, Operator, and Technician must have prior experience with the specific equipment, hardware and software installed under the contract.

1.4.1.2 Test Director

The Test Director must have at least five years of hands-on ESS experience to include any combination of design, installation, testing and maintenance.

1.4.1.3 Operator

The Operator must have at least two years of hands-on experience installing and maintaining ESS workstations to include both hardware and software. The Operator must be capable of demonstrating all workstation features and capabilities.

1.4.1.4 Technician

The technician must have at least two years of hands-on experience installing and maintaining ESS field equipment to include sensors, card readers, cameras, local processors, and communications equipment. The Technician must be capable of demonstrating all features and capabilities of ESS field equipment. Qualifications may be met by the individual experience of one technician or by the combined experience of a team of technicians.

1.4.1.5 Test Intruder

The purpose of the test intruder is to activate intrusion sensors in a realistic and repeatable manner. The test intruder must be between 70 and 72 inches tall and weigh between 175 and 190 pounds. The test intruder must possess sufficient physical strength, agility, and endurance to perform movements required for intrusion testing. These movements may include, but are not limited to, walking, running, crawling, jumping, and climbing.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 TEST PLAN

The Government will witness all system acceptance testing and endurance testing. Obtain written permission from the Government before proceeding with testing. Clearly establish the scope for ESS testing prior to beginning testing. Submit a Test Plan that addresses all testing requirements to include the following topics:

3.1.1 Personnel

Identify the Test Director, Operator, Technician, Test Intruder, and any other personnel that will be performing test activities.

3.1.2 Equipment

List all equipment that is required to support testing. State the purpose of each piece of equipment. Describe equipment that will be used to enable voice communications between the monitoring location and the field.

3.1.3 Procedures

Provide a step-by-step procedure for conducting each functional test. Describe actions and expected results. Ensure that functional test procedures address performance standards described in contract specifications especially any probability of detection (Pd) and nuisance and false alarm rate (NAR/FAR) requirements. Pd and NAR/FAR are not typically a concern for interior sensors installed per manufacturers specifications. For exterior sensors NAR/FAR needs to be verified but Pd may not need to be verified if installed IAW manufacturers or service specific guidance.

Download example procedures from

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic> and review for applicability and completeness. Adapt example procedures to meet specific project requirements and develop additional ones as needed. Follow TEST-MASTERTP0023-005 for Air Force projects.

3.1.4 Special Provisions

Discuss any special test provisions such as facility access, safety, integration with existing systems, and coordination with other work.

3.1.5 Test Logs

Provide logs for recording all data from functional testing and burn-in testing.

Download example logs from

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic> and review for applicability and completeness. Adapt example logs to identify each component by location to meet specific project components and system test requirements. Develop additional logs as needed.

3.1.6 Schedule

Provide an overall schedule that includes all testing milestones.

3.2 PRE-ACCEPTANCE TESTING

Conduct a complete test of all field equipment, workstations, and central system hardware and software in accordance with the approved Test Plan. The Test Director must be on site to conduct a pre-test inspection and oversee all testing activities. Prior to testing, visually inspect all ESS components and correct workmanship and neatness deficiencies as needed. During the pre-test inspection, verify the accuracy of redline drawings and update drawings as needed. Verify and document performance of each device and system feature to include sensor nuisance and false alarm rates. Review all positioning and field of view adjustments for each camera view in day and night operation.

Prepare and submit [Pre-Acceptance Test Certification](#) detailing the results of the testing. Refer to paragraph FINAL TEST REPORT for required content. Include a cover letter signed by the Test Director stating that pre-acceptance testing has been completed and that the system is ready for acceptance testing.

3.3 SYSTEM ACCEPTANCE

Test the ESS in accordance with the approved Test Plan in the presence of the Government Representative to certify acceptable performance. Verify that the total system meets all requirements of the specification and complies with the specified standards.

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<OLI>Demonstrate that the completed system complies with the contract requirements. Using approved test procedures, all physical and functional requirements of the project must be demonstrated and shown. The SAT, as specified, is not to be started until after receipt by the Contractor of written permission from the Government.</OLI>

<OLI>Begin acceptance testing upon arrival of the Government Representative at the project site. Place the ESS in normal operating mode and evaluate system performance during the testing period. Immediately report any deficiencies observed during testing to the Government Representative and discuss possible causes and corrective measures. Obtain Government approval prior to making any adjustments, repairs or modifications. The Government retains the right to terminate testing at any time the ESS is found to be incomplete or fails to perform as specified. Such termination of acceptance testing constitutes a FAILED system acceptance test.</OLI>

<OLI>Upon termination of testing by the Government or by the Contractor, commence an assessment period as described in paragraph Test Termination Assessment Period.</OLI>

<OLI>Upon successful completion of the system acceptance test, deliver test reports and other documentation as specified to the Government prior to commencing the endurance test.</OLI></OLG>

3.3.1 Test Termination Assessment Period

Identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the Government. Ensure that the report explains in detail the nature of each failure, corrective action taken, results of tests performed, and recommend the point at which testing should be resumed. After delivering the written report, convene a test review meeting to present the results and recommendations to the Government. Schedule the test review meeting at least 5 business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that all failures have been corrected by performing appropriate portions of the system acceptance test. Based on the Contractor's report and the test review meeting, the Government will determine the restart date, or may require that the entire test be repeated.

3.3.2 Preparation

Notify the Contracting Officer of system readiness 15 days prior to the expected start date of acceptance testing. Prior to acceptance testing, complete all clean-up and patch work requirements. Ensure that security equipment closets and similar areas are free of accumulation of waste materials or rubbish caused by prior installation work.

3.3.3 Personnel

Ensure that the following personnel are on site to perform test

activities: Test Director, Operator, Technician, and Test Intruder. Ensure that the Quality Control Manager is on site during acceptance testing.

3.3.4 Visual Inspection

Assist the Government Representative in conducting a visual inspection of ESS equipment and wiring. This inspection will focus on the general neatness and quality of workmanship and compliance with applicable codes and manufacturers' recommended installation methods. Provide a comprehensive listing of installed equipment and software, sorted by location, along with a complete set of ESS red line drawings to be used during the inspection. Document deficiencies identified during the inspection.

3.3.5 Phased Testing

3.3.5.1 Functional Testing

During the functional testing, verify system performance in accordance with the approved Test Plan. Record results in approved Test Logs and provide a written explanation of each failure to include cause, corrective action, and retest result. Continue functional testing until all tests have been successfully completed with no unresolved failures. Comply with requests from the Government Representative to repeat functional tests performed previously. The Government reserves the right to request the Contractor to repeat all functional tests or a representative sampling thereof as a means of performance verification. Document all test results on approved Test Logs.

3.3.5.2 System Activity Reports

Retrieve archived data from the system and provide unaltered activity reports as requested by the Government Representative. Reports may address any type of activity to include alarms, portal transactions, and video archives. Assist with analyzing reports to identify trends and anomalies.

3.3.5.3 Corrective Actions

Correct any deficiencies in coordination with the Government Representative. Maintain a punch list and review status at the end of each day. Work diligently to complete corrective actions the same day that deficiencies are observed. Add deficiencies not corrected on the same day to the rework items list maintained by the Quality Control Manager. Failure to resolve punch list items to the satisfaction of the Government constitutes a FAILED system acceptance test.

3.3.5.4 Endurance Testing

Following the successful completion of the functional test and completion of all corrective actions, monitor all components for a continuous period of 24 hours 5 days upon written approval from the government representative. Active monitoring will take place for a total of 8 hours per day and staggered throughout duty hours to sample normal operational and environmental site conditions during daytime and nighttime hours. All events, anomalies, and alarms will be reviewed, assessed in real time, and documented. Date and time of each activation will be recorded, assessed for cause, and noted. Events that occur outside the 8-hour window will be

assessed during the following work period. All cameras are to be reviewed for operability and clarity of view, day, and night.

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<OLI>The endurance test must demonstrate system reliability and operability. The endurance test will not be started until the Government notifies the Contractor, in writing, that the system acceptance test is satisfactorily completed, and correction of all outstanding deficiencies has been satisfactorily completed.</OLI>

<OLI>Provide 1 operator to operate the system 8 hours per day and staggered throughout duty hours to sample normal operational and environmental site conditions during daytime and nighttime hours in addition to any Government personnel that may be made available. The Government may terminate testing at any time if the system fails to perform as specified.</OLI>

<OLI>Upon termination of testing by the Government or by the Contractor, commence an assessment period as defined in paragraph Test Termination Assessment Period. Verify the operation of each terminal device during the last day of the test. Upon successful completion of the endurance test, deliver test reports and other documentation as specified to the Government prior to acceptance of the system.</OLI>

<OLI>The endurance test for sensors is required to demonstrate the configuration meets the requirements of Section 28 10 05 ELECTRONIC SECURITY SYSTEMS (ESS) paragraphs False Alarm Rate and Nuisance Alarm Rate. The Government Representative must be directly notified if any section of the fence exceeds the requirement. Upon coordination, re-calibrate the failed section, repeat functional test, and restart the endurance test period for that section.</OLI></OLG>

3.4 FINAL TEST REPORT

Submit a [Final Test Report](#) following the successful completion of acceptance testing to include all failures, remediation, and resolution of all punch list items. Address the following topics in the Final Test Report:

3.4.1 Summary

Provide a chronological summary of all testing. Describe test activities and results in narrative form.

3.4.2 Personnel

Provide a list of all Contractor and Government personnel who participated in the testing.

3.4.3 Test Logs

Provide all completed test logs along with a test log verification signed by the Test Director.

3.4.4 False and Nuisance Alarm Rates

Provide a tabulated and summarized listing of all events based on the system activity reports. Categorize every alarm as one of four types: 1) Valid/Actual, 2) False, 3) Nuisance, or 4) Test/Authorized Alarm.

3.4.4.1 Valid or Actual Alarm

An alarm received due to an actual intruder attempting to enter or entering a protected area or attempting to cross or crossing a line of detection.

3.4.4.2 False Alarm

An alarm received for which no cause can be determined. Typically, false alarms are due to aging or malfunctioning equipment and communications pathways that the alarm monitor cannot assess. False alarms in excess of established rates will cause complacency and lead to unsecure protected areas.

3.4.4.3 Nuisance Alarm

An alarm received due to an influence for which the sensor was designed to detect but which is not related to an intrusion attempt. The influence that caused the alarm must be clearly identifiable. These alarms fall into three categories: preventable, mitigatable, and unpreventable. Preventable nuisance alarms typically include personnel using improper entry/exit procedures, or an unauthorized incursion into the sensor zone. Preventable nuisance alarms must be included in the nuisance alarm rate. Mitigatable nuisance alarms can include: an animal entering into the sensor zone; a weather event typical/normal to the area, a noise event (i.e., a jet taking off in afterburner, a training explosion from the base range, etc.), or a seismic event (large vehicle vibrations from regular traffic in the area). Steps must be taken to reduce mitigatable events such as critter/animal control fences or animal abatement, bird abatement programs such as Bird/wildlife Aircraft Strike Hazard (BASH) or reprogramming the system to filter out certain vibrations/noises. Mitigatable nuisance alarms must be included in the nuisance alarm rate. Unpreventable nuisance alarms can include a weather event not typical/normal to the area (i.e., thunderstorm, hurricane, typhoon, etc.) or other atypical events to the area and will not be included in the nuisance alarm rate. Nuisance alarms in excess of established rates will cause complacency and lead to unsecure protected areas.

3.4.4.4 Test or Authorized Alarm

An alarm received due to authorized personnel performing required testing on the ESS. Tests can include daily, weekly, or monthly operational checks as well as acceptance, quarterly, semi-annual, or annual system functional checks.

3.5 Probability of Detection and Confidence Level

If Probability of Detection (Pd) requirements need to be validated, then Pd testing must be completed. The binomial table below uses a statistical method to determine Pd and Confidence level based on the number of sequential annunciated alarms due to test intrusions. Regulatory or contractual requirements will define the Pd and Confidence Level needed for specific zones or lines of detection. If the number of successive detections cannot be met without a missed detection, then adjustments to detection sensor coverage and sensitivity must be made.

Probability of Detection	0.9	0.9	0.95	0.95	Number of Misses Allowed
Confidence Level	90%	95%	90%	95%	
Number of Intrusion Attempts	22	29	45	59	0
	38	46	77	93	1
	52	61	105	124	2
	65	76	132	153	3
	78	89	158	181	4
	91	103	184	208	5

-- End of Section --

SECTION 28 10 05

ELECTRONIC SECURITY SYSTEMS (ESS)

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM B32 (2020) Standard Specification for Solder Metal

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3 (2022) Ethernet

IEEE C2 (2023) National Electrical Safety Code

INTELLIGENCE COMMUNITY STANDARD (ICS)

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ANSI ISO/IEC 7816 (R 2009) Identification Cards - Integrated Circuit Cards

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

NEMA ICS 1 (2022) Standard for Industrial Control and Systems: General Requirements

NEMA ICS 2 (2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 6 (1993; R 2016) Industrial Control and

Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National
Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 201-2 (2013) Personal Identity Verification
(PIV) of Federal Employees and Contractors

OPEN NETWORK VIDEO INTERFACE FORUM (ONVIF)

ONVIF (2017) Core Specification Version 17.06

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222 (2018H; Add 1 2019) Structural Standard
for Antenna Supporting Structures and
Antennas and Small Wind Turbine Support
Structures

TIA-568.2 (2018d) Balanced Twisted-Pair
Telecommunications Cabling and Components
Standards

TIA-606 (2021d) Administration Standard for
Telecommunications Infrastructure

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8500.01 (2014) Cybersecurity

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 50 (2015) UL Standard for Safety Enclosures
for Electrical Equipment,
Non-Environmental Considerations

UL 294 (2018; Reprint Oct 2018) UL Standard for
Safety Access Control System Units

UL 437 (2013; Reprint Oct 2017) UL Standard for
Safety Key Locks

UL 634 (2007; Reprint Mar 2015) Connectors and
Switches for Use with Burglar-Alarm Systems

UL 639 (2007; Reprint Nov 2019) Standard for
Intrusion Detection Units

UL 681 (2014; Reprint Jan 2021) UL Standard for
Safety Installation and Classification of
Burglar and Holdup Alarm Systems

UL 796	(2020; Reprint Aug 2021) UL Standard for Safety Printed-Wiring Boards
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1037	(2016; Reprint Sep 2017) UL Standard for Safety Antitheft Alarms and Devices
UL 1076	(2018; Reprint Feb 2021) UL Standard for Safety Proprietary Burglar Alarm Units and Systems
UL 1610	(2016; Reprint Apr 2021) UL Standard for Safety Central-Station Burglar-Alarm Units

1.2 SUBMITTALS

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

SD-02 Shop Drawings

ESS Components; G, D0

Overall System Schematic; G, D0

SD-03 Product Data

Premise Control Unit; G, D0

Detection Sensors; G, D0

Access Control Unit; G, D0

Access Control Devices; G, D0

Cameras; G, D0

Camera Lenses; G, D0

Camera Housing and Mounts; G, D0

Video Recording; G, D0

Workstation Computer; G, D0

Printers; G, D0

Communications Interface Devices; G, D0

Network Switch; G, D0

Video and ESS Transmission; G, D0

Uninterruptible Power Supply (UPS); G

Batteries; G, D0

Component Enclosure; G, D0

Equipment Rack; G, D0

SD-05 Design Data

Backup Battery Capacity Calculations; G, D0

NVR Storage Calculations; G, D0

Access Control Throughput Rates; G, D0

SD-07 Certificates

Contractor Qualifications; G, D0

Instructor Qualifications; G, D0

SD-10 Operation and Maintenance Data

Training Plan; G, D0

Training Content; G, D0

ESS Components and ESS Software: Data Package 4; G, D0

ESS Software and ESS Components: Data Package 4; G, D0

Submit data package in accordance with Section 01 78 23
OPERATION AND MAINTENANCE DATA

SD-11 Closeout Submittals

As-Built Drawings; G, D0

1.3 QUALITY ASSURANCE

1.3.1 Regulatory Requirements

The advisory provisions in each of the publications referred to in this specification are mandatory. Interpret these publications as though the word "must" has been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening, and have been utilized in applications of equipment and materials under similar circumstances and of similar size.
- b. Have been available on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer.
- d. Provide commercial off-the-shelf (COTS) products in which the manufacturer allows a network of qualified distributors to sell, install, integrate, maintain, and repair the hardware and software products that make up the system.

1.3.2.1 Alternative Qualifications

Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.3.2.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to the site are not acceptable.

1.3.2.3 Product Safety

System components are to conform to applicable rules and requirements of **NFPA 70**. Equip system components with instruction stickers including warnings and cautions describing physical safety, and special or important procedures to be followed in operating and servicing system equipment.

1.3.3 Shop Drawings

1.3.3.1 ESS Components

Submit the ESS Components, Data Package 4 with the ESS Software submittal package in accordance with Section **01 78 23** OPERATION AND MAINTENANCE DATA. Submit drawings that clearly and completely indicate each ESS component function that includes:

- a. Termination device points
- b. Interconnections required for system operation
- c. Interconnections between modules and devices
- d. Proposed wireway or conduit systems to be used including:
 - (1) Locations
 - (2) Sizes
 - (3) Types
- e. Drawings showing:

- (1) Device locations and spacing
- (2) Mounting and positioning details
- (3) Riser Diagrams with cable sizes and types
- (4) Bill of Materials (Device make, model and quantities)
- (5) Alarm and access control zones
- (6) IP Video Surveillance and sensor coverage areas
- (7) Spare capacity

1.3.3.2 Overall System Schematic

Indicate the relationship of integrated components on one-line diagram and show:

- a. Power source
- b. System controls
- c. Impedance matches
- d. Interconnecting wire data including:
 - (1) Number
 - (2) Size
 - (3) Identification
 - (4) Maximum lengths

1.3.4 Evidence of Experience and Qualifications

1.3.4.1 Contractor Qualifications

Submit experience and certified qualifications data prior to installation. Show that specific installers who will perform the work have a minimum of 2 years of experience successfully installing ESS of the same type and similar design as specified. **Additionally, installers must be certified by the ESS vendor/manufacturer.** Include the names, locations, and points of contact of at least two installations of similar type and design as specified in this document where the installer has installed such systems. Indicate the type of each system installed. Certify that each system has performed satisfactorily in the manner intended for a period of at least 12 months.

1.3.4.2 Instructor Qualifications

Submit the instructor's experience and certified qualifications data prior to installation. Show that the instructor has received a minimum of 24 hours of ESS training from a technical organization such as the National Burglar and Fire Alarm Association, and 2 years experience in installing the specified ESS type.

1.4 Environmental Conditions

1.4.1 Interior Conditions

Equipment installed in environmentally protected interior areas must meet performance requirements specified for the following ambient conditions:

1.4.1.1 Temperature

32 to 120 degrees F. Components installed in unheated security protected areas must meet performance requirements for temperatures as low as 0 degrees F

1.4.1.2 Pressure

Sea level to 15,000 feet above sea level

1.4.1.3 Relative Humidity

5 to 95 percent

1.4.1.4 Fungus

Components must be constructed of non fungus nutrient materials or be treated to inhibit fungus growth

1.4.1.5 Acoustical Noise

Components must be suitable for use in high noise areas above 100 dB, without adversely affecting their performance

1.5 SYSTEM CALCULATIONS AND ANALYSIS

1.5.1 Backup Battery Capacity Calculations

Submit calculations showing that backup battery capacity exceeds sensor operation, communications supervision, and alarm annunciation power requirements for proposed equipment plus 25 percent spare capacity.

1.5.2 NVR Storage Calculations

Submit calculations showing the required storage capacity for each video storage device.

1.6 ESS SOFTWARE, DATA PACKAGE 4

Submit the ESS software, Data Package 4 with the ESS Components submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Describe the functions of all software in the software manual and include:

- a. All information necessary to enable proper loading, testing, and operation
- b. Terms and functions definitions
- c. Use of system and application software
- d. Procedures for system initialization, start-up and shutdown

- e. Alarm reports
- f. Reports generation
- g. Database format and data entry requirements
- h. Directory of all files
- i. All communication protocol descriptions, including data formats, command characters, and a sample of each type of data transfer
- j. Interface definition
- k. List of software keys

1.7 AS-BUILT DRAWINGS

Maintain a separate set of drawings, elementary diagrams, and wiring diagrams of the system to be used for as-built drawings. Keep this set accurately and neatly up-to-date with all changes and additions. This set is not to be used for installation purposes.

Finish the final drawings submitted with the endurance test report in accordance with Section 01 78 00 CLOSEOUT SUBMITTALS for as-built requirements.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete electronic security system (ESS) that the meet requirements of Army Regulation AR 380-5 Department of the Army Information Security Program. Equipment, devices, and cabling shall be provided as part of Bid Option-ESS. Infrastructure (conduit, junction boxes, pull strings, etc.) shall be provided as part of the base bid. ESS consists of the following subsystems and features:

- a. Intrusion Detection System (IDS). The Intrusion Detection System (IDS) must be the army standard ICIDS-V manufactured by DAQ Electronics. The IDS must be separate from the ACS and Video Surveillance System.
- b. Access Control System (ACS). The Access Control System (ACS) must meet the security and functional requirements set by GSA's FIPS 201 Evaluation Program and must approved for use by the Federal Government (<https://www.idmanagement.gov/fips201/>). The ACS is prohibited from connecting to or transmitting over the Installation Network. Provide stand-alone ESS network (e.g., PoE network switches, patch panels, cabling) as part of the Access Control System and IP Video Surveillance System.
- c. IP Video Surveillance System. The IP Video Surveillance must comply with NDAA 2019. The IP Video Surveillance System is prohibited from connecting to or transmitting over the Installation Network. Provide stand-alone ESS network (e.g., PoE network switches, patch panels, cabling) as part of the Access Control System and IP Video Surveillance System.

- d. Security Command Center (SCC)
- e. Communications System

Include materials not normally furnished by the manufacturer with the ESS equipment as specified in:

- a. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

2.2 PERFORMANCE REQUIREMENTS

Provide the ESS systems to detect intrusion, control access, provide video surveillance, provide visual verification, and perform as an entity, as specified below. Provide electronic equipment that complies with 47 CFR 15 and are suitable for the environment where they will be installed.

2.2.1 Growth Capability

Provide capability for modular ESS expansion of inputs, outputs, card readers, and remote control stations with minimal equipment modification. Software must be able to handle design requirements plus 25 percent spare capacity. Growth capability is not to be limited by the provided products.

2.2.2 Network Certification

Certify all Platform Information Technology (PIT) in accordance with DODI 8500.01 and the individual service implementation policy.

2.2.3 Maintainability

Provide components that can be maintained using commercially available tools and equipment. Arrange and assemble components to be readily accessible to maintenance personnel without compromising system defeat resistance and with no degradation in tamper protection, structural integrity, EMI or RFI attenuation, or line supervision after maintenance when it is performed in accordance with manufacturer's instructions.

2.2.4 Availability

Provide components rated for continuous operation. Provide solid-state electronic components mounted on printed circuit boards, conforming to UL 796. Provide boards that are plug-in, quick-disconnect type. Do not impede maintenance with densely packed circuitry. Provide power-dissipating components with safety margins of not less than 25 percent with respect to dissipation ratings, maximum voltages, and current-carrying capacity. Provide solid-state type or hermetically sealed electromechanical type light duty relays and similar switching devices.

2.2.5 Fail-Safe Capability

Provide fail-safe capability in critical elements of the ESS including, but not be limited to, the capability to monitor communication link integrity and to provide self-test. Provide fault annunciation when diminished functional capabilities are detected. Annunciate fail-safe alarms to clearly distinguish from other types of alarms.

2.2.6 Line Supervision

Provide the same geographic resolution for fault isolation at the systems level as provided for intrusion detection. Provide either a static or dynamic system with active mode for line supervision of communication links of the ESS.

- a. The static system must represent "no-alarm" always by the same signal, which is different than the originally transmitted signal.
- b. The dynamic system must represent "no-alarm" with a signal which continually changes with time.

2.2.7 Power Loss Detection

Detect AC and DC power loss and generate an alarm when a critical component of the system experiences temporary or permanent loss of power. Annunciate the alarm in the Security Command Center to clearly identify the component experiencing power loss.

2.2.8 Controls and Designations

Provide controls and designations as specified in [NEMA ICS 1](#).

2.2.9 Special Test Equipment

Provide all special test equipment, special hardware, software, tools, and programming or initialization equipment needed to start or maintain any part of the system and its components. Special test equipment is defined as any test equipment not normally used in an electronics maintenance facility.

2.2.10 Electromagnetic Interference (EMI)

Configure and provide ESS components employing electromagnetic radiation constructed to provide minimal vulnerability to electronic countermeasures.

2.2.11 Electromagnetic Radiation (EMR)

Provide only ESS communication components which are Federal Communications Commission (FCC) licensed and approved. Provide system components which are electromagnetically compatible.

2.2.12 Interchangeability

Use off-the-shelf components which are physically, electrically, and functionally interchangeable with equivalent components as complete items. Equivalent, replacement components must not require new or other component modification. Do not use custom designed or one-of-a-kind items. Interchangeable components or modules must not require trial and error matching in order to meet system requirements, system accuracy, or restore complete system functionality.

2.3 INTRUSION DETECTION SYSTEM (IDS)

The IDS primary function is to detect intrusion into secured areas. Utilize a single database for all IDS programming data. [The IDS shall be 100% fully compatible with the Installation's ICIDS system.](#) The IDS events must be viewable as separate or as a combined list of all ESS

events. Control the IDS alarm monitoring through software control from the ESS.

- a. Provide both supervised and non-supervised alarm point monitoring.
- b. Arm or disarm and secure or access alarm points both manually and automatically by time of day, day of week or by operator command.

2.3.1 IDS Components

Provide components:

- a. Premise Control Units (PCU)
- b. Detection Sensors
- c. Tamper Switches
- d. Keypad with cover

2.3.2 Detection Sensitivity

The sensitivity of the IDS must allow for the following:

- a. Locating intrusions within building's secure areas.
- b. Locating intrusions at individually protected assets or at an individual portal
- c. Locating intrusions within the coverage on a single volumetric sensor
- d. Locating failures or tampering at individual sensors

2.3.3 Detection Alarm and Reporting Capacity

Collect, communicate, and display up to 12 sensor zone alarms.

Identify individual sensors in alarm if the sensor zone is a multiple alarm source combination. Annunciate a single alarm within 1 second maximum, after sensor transducer or other detection device activation.

2.3.4 False Alarm Rate

The false alarm rate for each interior IDS zone must not exceed one false alarm per 30-day period. The false alarm rate for each exterior IDS zone must not exceed one false alarm per 24-hour period.

2.3.5 Nuisance Alarm Rate

The nuisance alarm rate for each interior IDS zone must not exceed three nuisance alarms per 30-day period. The nuisance alarm rate for each exterior IDS zone must not exceed three nuisance alarms per 24-hour period.

2.3.6 Premise Control Unit (PCU)

Install the PCU command processor in a tamper resistant enclosure that is specified in paragraph "Component Enclosure". Package the following with the PCU:

- a. Power transformer
- b. Battery(s)
- c. Network connection cable
- d. Keypad(s)
- e. Keypad connection cable(s)
- f. Additional components as required for full functionality

2.3.6.1 PCU Capabilities

Provide the PCU at a minimum but not limited to, the following capabilities;

- a. Expansion to a total of at least 10,000 user codes with 99 user profile definitions.
- b. Support 4 keypads with alphanumeric display. Each keypad must be capable of arming and disarming and securing and accessing any system area based on a pass code or access control card and or key FOB authorization. Provide keypad alphanumeric display with complete prompt messages during all stages of operation and system programming and display all relevant operating and test data.

2.3.6.1.1 PCU Interface

PCU shall interface with space door lock to control access into secure space.

- a. 2 individual reporting areas.
- b. Encrypten NEC circuits.
- c. Two-man access code or credentials.
- d. Support programming to require the same or different access code entered within a programmed delay time of 1 to 15 minutes after disarming before activating a silent ambush alarm.
- e. Support area programming that disables schedule and time-of-day changes while system is armed so that area can only be disarmed during scheduled times.
- f. Provide a minimum of a 4,000 event log buffer per PCU. Record and hold alarm activity information in the log buffer until the ESS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for PCU(s) configured with network switch capabilities.

2.3.6.2 Overcurrent Protection and Indication

When overcurrent more than it is rated for is detected by the PCU, communication bus(es) and keypad(s) are to be shut down and an overcurrent notification LED lit to indicate the situation.

2.3.6.3 Manual and Self-Test

All testing from any alphanumeric keypad include testing for: standby battery, alarm bell or siren, and communication to the Security Command Center (SCC). Include provisions for an automatic, daily, weekly, 30 day, or up to 60 day communication link test from the PCU installation site to the SCC. Include a provision for displaying the internal system power and wiring conditions.

Include the following for internal monitoring points:

- a. The bell circuit
- b. AC power
- c. Battery voltage level
- d. Charging voltage
- e. Panel box tamper
- f. Communication loss/fail

A battery test must be automatically performed to test the integrity of the standby battery by disconnecting the standby battery from the charging circuit and placing a load on the battery. Perform this test at an interval no greater than 180 days.

2.3.7 Detection Sensors

- a. Sensors are to detect facility perimeter or protected zone penetrations by unauthorized personnel or intruders and transmit an alarm signal to the alarm annunciation system upon change detection. Accomplish this with a probability of detection (PD) of 0.9 with a 95 percent confidence level and conforming to UL 639 where applicable.
- b. Required sensor power is 12 VDC unless otherwise specified.
- c. An interior IDS zone is a room or space within a building that can be armed and disarmed and secured and accessed independently from all other zones.
- d. Provide line supervision for all sensors with an end-of-line resistor at the sensor or within a tampered junction box with conduit from the junction box to the sensor.
- d. Provide sensors and components rated for operation in the installed environment. The sensors must transmit an alarm signal to the alarm annunciation system upon change detection. Provide all sensors with a tamper switch and elements housed in a tamper-alarmed enclosure in accordance of paragraph "Component Enclosure".

2.3.7.1 Interior Sensors

2.3.7.1.1 High Security Switch (HSS)

HSS must be UL 634 Level 2 high security switches. Provide 2 sets of contacts to permit both ACS and IDS connection to each HSS. Mount the HSS inside the secure location and on the opening side of the door. HSS

sensors do not have the capability to incorporate an end-of-line (EOL) resistor.

2.3.7.1.2 Passive Infrared Sensors

UL 639.

2.3.7.2 Tamper Switches

- a. Corrosion-resistant tamper switches are required for the following IDS, access control, and video surveillance equipment with hinged doors or removable covers that contain open circuits:

- (1) Enclosures
- (2) Cabinets
- (3) Housings
- (4) Boxes
- (5) Raceways
- (6) Fittings
- (7) Sensors

- b. Tamper switches are to initiate an alarm signal when the door or cover is moved as little as 1/4 inch from the normally closed position. Mechanically mount tamper switches to maximize defeat time when enclosure covers are opened or removed. One second is the minimum amount of time required to depress or defeat the tamper switch after opening or removing the cover. Enclosure and tamper switch must prevent direct line of sight to internal components and prevent switch or circuit tampering. Conceal mounting hardware so switch cannot be observed from enclosure exterior.
- c. Tamper switches on doors which are opened to make normal maintenance adjustments to the system and to service power supplies must not have a maintenance position. Provide two positions tamper switches.

2.3.7.2.1 Tamper Switch Performance Requirements

Tamper switches are to be:

- a. Inaccessible until switch is activated.
- b. Under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating.
- c. Annunciated to be clearly distinguishable from intrusion detection alarms and exempt from being disarmed, shunted, or silenced.
- d. Spring-loaded and held in the closed position by the door, or cover protected.
- e. Wired to break the circuit when the door or cover is disturbed.
- f. Wired so that each sensor and device is annunciated by zone at the

central reporting processor.

2.3.8 Keypad with Cover

IDS keypads must have alphanumeric display and cover to prevent unauthorized observation of pass code entry. Each keypad must be capable of arming and disarming and securing and accessing any system area based on a pass code or access control card and or key FOB authorization. Provide keypad alphanumeric display with complete prompt messages during all stages of operation and system programming and display all relevant operating and test data.

2.4 ACCESS CONTROL SYSTEM (ACS)

Provide an access control system based upon a modular distributed microprocessor architecture complete with access control cards and ready for operation.

- a. The ACS card credentials are required to be Common Access Cards (CAC), and CAC cards are being provided by the Government. Interface system with and provide alarm and other status to the overall ESS. Provide ACS that meets the communications requirements of [UL 1076](#) and [UL 294](#) and has the capability of controlling the required number of card readers and keypads, alarm inputs, relay outputs and other components.
- b. System is to grant or deny access or exit based upon:
 - (1) Keypad identification data
 - (2) CAC card identification data
 - (3) Input through the access control devices compared to data stored within the system
 - (4) Time of day, day of week, and special day and holiday scheduling with card validation override.
- c. Decision to grant or deny access or exit is to be based upon authorization for such data to be input at a specific location for the current time period.
- d. Provide ACS that supports the configuration and simultaneous monitoring of multiple access control devices when TCP/IP communication interfaces are used between the ESS and the primary Access Control Unit (ACU). The events of the ACS are to be viewable as separate or as a combined list of all ESS events. Provide overall control of the ACS, alarm monitoring, and photo identification through software control of the ESS.
- e. Access control, photo imaging, and programming data must reside on a single database and instantly accessible to every networked PC workstation connected to the ESS.
- f. Provide both supervised and non-supervised alarm point monitoring.
- g. Provide the capability to arm or disarm alarm points both manually and automatically by time of day, day of week or by operator command and the capability to disarm alarm points based on a valid access event.

- h. Provide programmable 'delay' setting for all alarm points. The alarm points are not to report an ENTRY type alarm until the delay setting has expired and not report a dwell type alarm condition until the alarm has been active for the full delay period.
- i. Provide the capability to place ACU(s) in an off-line mode. In the off-line mode, the ACU(s) must retain a historical summary of all ACU activity transactions, up to the maximum capacity of the ACU memory buffer. Provide the ability for manual operator control of system output relays with the manual functions to energize, de-energize, enable or disable.

2.4.1 ACS Programming

Provide software capable of, but not limited to, the following programming:

2.4.1.1 Time Schedules

Provide up to 256 user-definable time schedules. These time schedules are to determine the day(s) and times that access will be granted or a scheduled event is to occur. Any and all of the time schedules are to be available for defining access privileges and scheduled events. Provide ALWAYS and NEVER schedules that cannot be altered or removed from the system. Each user-defined time schedule must have the option of reacting or not reacting to user-defined special days, with the ability to react uniquely to each type of special day.

2.4.1.2 Special Days

Provide an unlimited number of user definable special days to be used for configuring exceptions to the normal operating rules, typically for specifying holiday operating rules. Allow for each special day to be assigned to a user-defined type.

2.4.1.3 ACU Daylight Savings Time Adjustment

Provide a software-configurable, user defined adjustment for Daylight Savings Time. The ACU must not need to be connected to a PC workstation in order for the adjustment to occur.

2.4.1.4 Scheduled Events

Any access controlled reader is to be capable of scheduled unlock periods to allow for card-free access. The access controlled reader is to also be capable of requiring one valid access event before beginning a scheduled unlock period.

Any access control point is to be capable of requiring a valid card as well as a PIN code via keypad on a scheduled basis for high security areas. The use of PIN via keypad functions must not reduce the number of card readers or alarm points available in the ACU(s). Any designated alarm input must be able to be scheduled Secured and Accessed. Any relay output must be capable of scheduled ON and OFF periods to allow for automatic input and output system control.

2.4.1.5 Maximum User Capability

Up to 1,000 individual users may be given access cards or codes and have their access controlled and recorded.

2.4.1.6 Access Groups

Each system user must be assignable to a maximum of 4 of 256 possible access groups. An access group is defined as one or more people who are allowed access to the same areas at the same days and time periods.

2.4.1.7 Active and Expire Dates

Any card or user may be configured with activation and expiration dates. The card can be assigned to any valid access group and will be activated and expired according to the specified dates.

2.4.1.8 Maximum Use Settings

Any card or user may be configured with maximum number of uses for that card. The card can be assigned to any valid access group and will be expired according to the specified number of card uses.

2.4.1.9 Door Outputs

Provide each access control reader with two dedicated relay outputs. Both relays are to provide Normally Open and Normally Closed contacts. Use the first relay for electric lock control while the second is software configurable to activate for door forced open, door left open too long, duress, passback violations, invalid access attempts and valid unlock conditions. Allow for both relays to be separately programmable for energize times from 1 second to 10 minutes. The second relay must allow a delay time to be specified, causing its activation to be delayed after an activating condition occurs.

2.4.1.10 Anti-Passback

Provide global anti-passback capability. Any door on the system can be linked to one of 256 user defined passback areas or two 2 pre-defined areas. Each door may be set up to automatically forgive passback entries at one of the following intervals:

- (1) Never
- (2) Midnight
- (3) Every 12 hours (Midnight and Noon)
- (4) Every 6 hours
- (5) Every 2 hours
- (6) Each hour
- (7) Every 30 minutes

Each door can be configured to deny or grant access for passback violations and individual users can be exempt to the passback rules. The anti-passback features must be a global function and operate completely independent of the ACS software, except configuring the passback rules. Additionally, the operator is to have the ability to manually forgive an individual user or all users by command from the ACS.

2.4.1.11 User List or Who's In (Muster Reports)

Provide the capability to generate dynamic lists of users in certain access-controlled areas, based either upon selected users or selected areas. The lists must have the option of automatically refreshing after a user-selected interval of time.

2.4.1.12 Crisis Mode

Provide support for a "crisis mode", in which user-selected alarm point activations cause changes to user access privileges. The changes to user access privileges must be configurable to restrict normal access to no access or limited access.

2.4.1.13 Door Groups

Allow up to 256 door groups to be configured. Doors belonging to the same group are able to be locked, unlocked, disabled, and enabled on command from the ACS.

2.4.1.14 Door Interlocking

Allow a group of doors to be software configured so that if any door in the group is unsecure, all other doors are automatically disabled. This feature is also known as a "mantrap" configuration. The interlocking features must not require the ACS to be on-line for proper operation.

2.4.1.15 PIN Required

Provide support for the required use of a keypad code, in addition to a valid credential during user-selected schedules.

2.4.1.16 Remote Door Control

Provide the ESS operator the capability of manually controlling any access point by issuing a simple command from the ACS. Provide the operator the ability to lock, unlock, enable, and disable any door or Door Group in this manner. This activity is to cause an entry to be logged displaying the door name, number and time that it was performed.

2.4.1.17 Key Control

When interfaced with an approved key-control system, the system is to allow users to deny access to certain doors for any users who have keys in their possession.

2.4.1.18 Reader Disable

Provide support for disabling readers in reaction to a user-selected number of invalid access attempts.

2.4.1.19 Disable Event Messages

Allow users to disable user-selected event messages (Door Forced Open, Door Open Too Long, Door Closed, Request to Exit) for user-selected doors. Allow users to disable certain messages (Door Forced Open, Door Open Too Long) according to a user-selected schedule.

2.4.1.20 Input and Output Groups

Allow for up to 256 user-defined (input and output) groups to be defined. Each Input device is to be able to be linked to these groups for arming, disarming, shunting and unshunting as well as output control.

2.4.1.21 Delays

Each alarm device must allow a delay to be specified which is either an entry type or a dwell type. An entry-type delay is to prevent the input from issuing an alarm event until the delay elapses. If unarmed during the delay period, the alarm is to be ignored. A dwell-type delay requires the input to remain in the alarm state for the full delay duration before issuing an alarm.

2.4.1.22 Remote Input Control

Provide the operator the capability of manually controlling any alarm, input point, alarm partition or group by issuing a simple command from the SCC on the ACS allowing the ability to shunt, unshunt, disable and restore any input in this manner. This activity must cause an entry to be logged displaying the input name and time that it was performed.

2.4.1.23 Output Configuration

Allow each output relay to be software configurable as:

- (1) Follows
- (2) Latch
- (3) Timeout
- (4) Scheduled
- (5) Timeout Re-triggerable
- (6) Limit
- (7) Counter

Allow for a time schedule to automatically control the activation and de-activation of the Scheduled type with all other types configured to activate based on input and output group conditions. Additionally, a time schedule must be specified to configure when the output is to actively monitor the input and output groups.

2.4.1.24 Remote Output Control

Provide the operator the capability of manually controlling any output point by issuing a simple command from the SCC. Based upon the output type, provide the ESS operator the ability to ENABLE, DISABLE, turn ON and turn OFF any output in this manner. A FOLLOWS type output must not be capable of being turned OFF or ON. Log an entry when this activity is performed displaying the output name and time performed. Manual control of outputs are not permissible in ICS 705-1 applications.

2.4.1.25 Remote Reset Command

Provide the capability for any ACU to reset manually or by command issued from the ACS with the option of simulating the ACU reset settings, or forcing a reset type as specified by the user. The remote reset command is not to cause the ACU to degrade its level of protection to any access points defined.

2.4.1.26 Time Zone

Allow the user to select the time zone in which the ACU is located, so that event times displayed for that ACU will match the local time where the ACU is located.

2.4.1.27 User-Selected LED Behavior

Allow the user to select different behaviors for the LEDs of each access controlled reader.

2.4.1.28 Traced Cards

Provide the capability of selecting any number of cardholders for the purpose of limiting reports to only traced users displaying all traced cardholder events in a user-selected alternate color.

2.4.2 Error and [Throughput Rates](#)

Rates must be portal to portal performance averages obtained when processing individuals one at a time. Features are not to reduce capability to meet throughput requirements when serial verification techniques or multiple attempts are required to satisfy error performance requirements.

A Type I error denies access to an authorized enrolled individual. A Type II error grants access to an unauthorized individual. Subsystem Type I and Type II error rates must both be less than 0.1 percent. At the error rates, subsystem access throughput rate must be minimum of 12 individuals per minute through one card reader and keypad access control device.

2.4.3 Access Control System Central Processing

- a. Provide serial management and control of system processing. Provide a microprocessor control device able to monitor and control units and up to [the required number of](#) card reader and keypad access control devices. Central processor must interrogate and receive responses from each ACU within 100 milliseconds. Failure to respond to an interrogation is to cause an alarm.
- b. Provide the central processor with a USB interface port to communicate with the printer. Provide an operator interface to control system operating functions. Provide the central processor with a facility-tailorable data base for a minimum of 1000 cardholders with by-name alphanumeric printout, and for automated IDS monitoring, management, and control functions.
- c. Provide enrollment equipment as required in paragraph ENROLLMENT CENTER EQUIPMENT.
- d. Provide system configuration controls and electronic diagnostic aids

for subsystem setup and troubleshooting with the central processor. Components are not to be accessible to operations personnel and must be tamper alarmed.

2.4.4 Access Control Unit(ACU)

UL 294. Provide micro-processor based ACU with all access and input and output decisions to be made by the individual ACU(s). Provide modular solution which will allow for present security requirements and the capability to expand. Configure all field ACU panels to intercommunicate via RS-422/485, TCP/IP or fiber-optic communication. Equip all field ACU(s) with a tamper contact.

Designate one ACU as "Primary", responsible for all ACS-to-ACU communications. All other ACU(s) up to a maximum of 64 are to be designated as "Secondary" and communicate with the "Primary" via an RS-422/485 hardwire, TCP/IP network or fiber-optic configuration. Provide ACU capable of, but not limited to, the following:

- a. Built-in surge suppression circuitry on plug-in modular circuit boards with surge suppression, configured as an integral component of the system and self-sacrificing in the event of extreme surges or spikes.
- b. Capable of supporting at least 2 ports and be expandable in increments of two ports up to a maximum of 8 ports per ACU.
- c. Each port configured by ACS to support any one of the following peripheral devices:

- (1) Card reader
- (2) Alarm Monitoring Module
- (3) Output Relay Module

Any device combination can be supported on each ACU, up to a total of 8 devices per ACU.

- d. Capability of supporting multiple card reader technologies simultaneously, including:

- (1) Keypad
- (2) Card and Keypad
- (3) CAC compatible
- (4) Biometrics

This capability must be an integral part of the ACU and will not require special external equipment.

- e. Built-in battery back-up of programmed information sustainable for a period of at least 90 days.
- f. Powered by a 24 VDC power source rated at a minimum of 2 amperes with a battery back-up for complete system operation in the event of power failure. Provide battery backup for all ACU(s) to sufficiently power the ACU for 8 hours continuous service.

- g. Electric strikes, other locking devices and ancillary peripherals on a separate power supply with battery back-up for continued operation in the event of power failure as specified in paragraph "Backup Power".
- h. A minimum of a 10,300 event log buffer per ACU to record and hold access and alarm activity information until the ACS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for ACU(s) configured with network switch capabilities.

2.4.5 Access Control Devices

UL 294. The card, card reader, and panels must meet encryption requirements that are specified in paragraph DATA ENCRYPTION. Devices are to be tamper alarmed, tamper and vandal resistant, and solid state, containing no electronics which could compromise the access control subsystem should the subsystem be attacked.

2.4.5.1 Card Readers

Provide surface or weatherproof mountable card readers as indicated for each individual location. Provide combination contact and contactless type card readers capable of reading CAC cards type of access control cards.

Keypads must contain an alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence. Provide keypad integrated into the card reader.

2.4.5.1.1 Contact Card Readers

Provide contact card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 and are in compliance with NIST FIPS 201-2.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.2 Contactless Card Readers

Provide contactless card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 in close proximity to the card reader and are in compliance with NIST FIPS 201-2.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.3 Card Reader Display

Provide card readers with an LED or other visual indicator display which indicate power ON and OFF and whether user passage requests have been accepted or rejected.

2.4.5.1.4 Card Reader Response Time

The card reader is to respond to passage requests by generating a signal to the local processor.

2.4.5.1.5 Card Reader Power

Power the card reader from the source as shown on the drawings. The card reader must not dissipate more than 5 Watts.

2.4.5.1.6 Card Reader Mounting Method

Provide card readers suitable for surface or weatherproof mounting as required.

2.4.5.2 Keypads

Entry control keypads are to use unique alphanumeric and other symbol combinations as an identifier. Keypads must contain an integral alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence. Communications protocol is to be compatible with the local processor.

2.4.5.2.1 Keypad Display

Keypads are to include an LED or other type of visual indicator display and provide visual and audible status indications indicating power ON and OFF and whether user passage requests have been accepted or rejected.

The maximum horizontal and vertical viewing angles are to be limited by the keypad display or enclosure. The maximum horizontal viewing angle must be no more than plus and minus 5 degrees off a vertical plane perpendicular to the plane of the face of the keypad display. The maximum vertical viewing angle must be no more than plus and minus 15 degrees off a horizontal plane perpendicular to the plane of the face of the keypad display.

2.4.5.2.2 Keypad Response Time

The keypad is to respond to passage requests by generating a signal to the local processor.

2.4.5.2.3 Keypad Power

Power the keypad from the source as shown on the drawings. The keypad must not dissipate more than 5 Watts.

2.4.5.2.4 Keypad Mounting Method

Provide keypads suitable for surface or weatherproof mounting as required.

2.4.5.2.5 Keypad Duress Codes

Provide a means for users to indicate a duress situation by entering a special code into the keypad.

2.4.5.3 Card Readers with Integral Keypad

Equip contact and contactless card readers with integral keypads as

specified in paragraph "Keypads".

2.4.5.4 Portal Control Devices

Portal control devices must meet the requirements in Section 08 71 00 DOOR HARDWARE.

2.4.5.4.1 Panic Bar

Include panic bar emergency exit hardware on emergency exit doors as indicated. Provide an alarm shunt signal from the panic bar emergency exit hardware to the appropriate local processor.

2.4.5.4.1.1 Emergency Egress With Alarm

Include a conspicuous warning sign with 1 inch high, red lettering notifying personnel that an alarm will be annunciated if the panic bar is operated.

Panic bar hardware operation is to generate an intrusion alarm. The panic bar must depend upon a mechanical connection only and not depend upon electric power for operation, except for local alarm annunciation and alarm communications.

2.4.5.4.1.2 Normal Egress

Panic bar hardware operation is not to generate an intrusion alarm. The panic bar must depend upon a mechanical connection only when exiting. Provide the exterior, non-secure side of the door with an electrified thumb latch or lever to provide access after the credential I.D. authentication by the ESS.

Signal Switches: Strikes/bolts are to include signal switches indicating to the system when the bolt is not engaged or the strike mechanism is unlocked. The signal switches are to report a forced entry to the system.

2.4.5.4.2 Electrified Mortise Lock

Configure electrified mortise locks with integral REX feature as specified in Section 08 71 00 DOOR HARDWARE. Provide solenoids rated for continuous duty. Incorporate end-of-line resistors to facilitate line supervision by the system. Install metal-oxide varistors (MOVs) to protect the controller from reverse current surges if not incorporated into the electric strike or local controller.

2.4.5.4.2.1 Solenoid

The actuating solenoid for the mortise locks furnished must not dissipate more than 12 Watts and operate on 12 or 24 VDC as required. The inrush current must not exceed 1 ampere and the holding current must not be greater than 500 milli-amperes. The actuating solenoid must move from the fully secure to fully open positions in not more than 500 milliseconds.

2.4.5.4.2.2 Signal Switches

The mortise locks are to include signal switches indicating to the system when the locks are not engaged. The signal switches are to report a forced entry to the system.

2.4.5.4.2.3 Electric Power Transfer (EPT)

Provide an electric power transfer with each mortise lock in order to get power and monitoring signals from the lockset to the door frame.

2.4.5.4.2.4 Size and Weight

Electrified mortise locks are to be compatible with standard door preparations.

2.4.5.4.2.5 Mounting Method

Provide electrified mortise locks suitable for use with single and double door installations. The lock would be in the active leaf and the fixed leaf would be monitored in double door installations.

2.5 IP VIDEO SURVEILLANCE SYSTEM

Select system components that conform to the Open Network Video Interface Forum (ONVIF) specification. Provide compatible UL listed video surveillance components to provide visual assessment of ESS alarms automatically upon alarm or upon SCC operator selection. Otherwise, the subsystem is to continuously display the coverage area. Display alphanumeric camera location ID on all monitors. Provide the number of alarm monitors as required. The scene from each camera must appear clear, crisp, and stable on the respective monitor during both daytime and nighttime operation. Provide component equipment that minimizes both preventive and corrective maintenance. Provide components from a single manufacturer or justify mixing manufacturer components and demonstrate compatibility in submittal information.

2.5.1 Cameras

2.5.1.1 IP Video Surveillance Camera

Provide cameras of digital fixed, pan-tilt-zoom (PTZ), or panoramic type as identified on the drawings.

- a. Day-Night Color fixed, PTZ or panoramic cameras are to be used in all outdoor environments. Standard fixed, PTZ, or panoramic cameras are to be used for all indoor applications except when backlighting issues are observed. Use Day-Night cameras or standard cameras with backlighting compensation for backlighting or high contrast applications.
- b. Provide PTZ cameras with a direct drive motor assembly. Belt driven PTZ camera units are not acceptable. Equip PTZ cameras with a slip ring assembly having an optical interface and be rated for continuous duty. PTZ cameras have to be fully integrated units. The pan-tilt mechanism must be an integral part of the camera.
- c. Provide cameras that operate on Power over Ethernet (PoE) IEEE 802.3.
- d. All cameras must be constructed to provide rigid support for electrical and optical systems so that unintentional changes in alignment or microphonic effects do not occur during operation, movement, or lens adjustments.
- e. Video Frame Rate: 30 frames per second (fps)

f. Minimum essential requirements for cameras include the following:

2.5.1.1.1 Sensitivity

Minimum Illumination: 0.08 foot-candles at F1.4 color mode; 0.01 foot-candles at F1.4 in the B&W mode.

2.5.1.1.2 Signal-To-Noise Ratio

Show a signal-to-noise ratio of not less than 50 decibels (dB) at Automatic Gain Control (AGC) "Off", weight "On".

2.5.1.1.3 Resolution

Provide a minimum of 2.1 megapixel resolution. The imager must have a minimum of 1920 horizontal x 1080 picture in progressive scan format. Resolution is to be maintained over the specified input voltage and frequency range, and not vary from minimum specification over the specified operating temperature range.

2.5.1.1.4 Synchronization

Provide cameras that have internal and line lock.

2.5.1.1.5 Low Light Level

Provide Day-Night cameras that have a B-W mode that may be automatically engaged on low light level and permit the use of an external infrared illuminator. Electronic removal of the color signal is not acceptable. The camera must have an infrared cut filter capable of being removed automatically upon low light threshold or manually.

2.5.1.2 Camera Lenses

Camera lenses are to be all glass with coated optics. Provide lens mount that is C or CS mount, compatible with the cameras selected or integrated with the cameras. Provide lens with the camera that have a maximum f-stop opening of f/1.2 or the maximum available for the focal length specified. The lens is to have an auto-iris mechanism unless otherwise specified. Lenses having auto iris, manual iris, or zoom and focus functions are to be supplied with connectors, wiring, receiver and driver units, and controls as needed to operate the lens functions. Provide lenses with sufficient circle of illumination to cover the image sensor evenly. Lenses are not to be used on a camera with an image format larger than the lens is configured to cover. Provide lens with focal lengths as indicated or specified in the manufacturer's lens selection tables.

2.5.1.3 Camera Housing and Mounts

The camera and lens are to be enclosed in a tamper resistant housing installed on a camera support. Any ancillary housing mounting hardware needed to install the housing at the camera location is to be provided as part of the housing. The camera support must be capable of supporting the mounted equipment and withstanding wind and ice loads normally encountered at the site.

2.5.1.3.1 Environmentally Sealed Camera Housing

The housing is to provide an environment needed for camera operation and be condensation free; dust and water tight; keep the viewing window free of fog, snow, and ice, and be fully operational in 100 percent condensing humidity. Provide housing equipped with a sunshield. Both the housing and sunshield are to be white. Purge the housing of atmospheric air and pressurized with dry nitrogen, equipped with a fill valve, overpressure valve, and include a humidity indicator visible from the exterior. Housing must not have a leak rate greater than 2 psi at sea level within a 90 day period.

Provide housing equipped with supplementary camera mounting blocks or supports needed to position the camera and lens to maintain the proper optical centerline. All electrical and signal connections required for camera and lens operation are to be supplied. Provide a mounting bracket as part of the housing which allows weight adjustment to center the weight of the assembly.

2.5.1.3.2 Indoor Camera Housing

Provide housing with a tamper resistant enclosure for indoor camera operation and with the proper mounting brackets for the specified camera and lens. The housing and appurtenances color are not to conflict with the building interior color scheme.

2.5.1.3.3 Interior Mount

Provide camera mount suitable for either wall or ceiling mounting and have an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum or steel with a corrosion-resistant finish. Provide adjustable head with 360 degrees of pan and plus or minus 90 degrees of tilt.

2.5.1.3.4 Low Profile Ceiling Mount

Provide tamperproof ceiling housing which is low profile and suitable for use in 2 by 2 foot ceiling tiles. The housing must be equipped with a camera mounting bracket and allows a 360 degree viewing setup.

2.5.1.3.5 Interior Dome Housing

The dome housing is to be capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings. The lower dome is to be black opaque acrylic and have a light attenuation factor of not more than 1 f-stop. Provide housing with:

- a. Integral pan-tilt complete with wiring
- b. Wiring harnesses
- c. Connectors
- d. Permanent lubrication
- e. Motors that are thermally or impedance protected against overload damage.
- f. Any other hardware and equipment as needed to provide a fully

functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.2 Color Video Monitors

Except as specified, provide video monitors that:

- a. Are rated for continuous operation and incorporate printed circuit board modular construction.
- b. Have printed circuit modules that are easily replaceable.
- c. Use solid-state devices for electronic circuits.
- d. Are constructed to provide rigid support for electrical systems so that unintentional changes in alignment or microphonic effects will not occur during operation or movement.
- e. Incorporate circuit safety margins of not less than 25 percent where possible, with respect to power dissipation ratings, voltage ratings, and current carrying capacity.
- f. Have a diagonal viewing angle that nominally measures 24 inches for monitors, LED displays.
- g. Provide adequate safeguards to protect personnel from exposure to line voltage during operation or adjustment.
- h. Have at least the following essential requirements:
 - (1) Resolution for LED monitors to be: 17 inch monitors - 1280x1024, 500 TV lines (maximum); 20.1 inch monitors - 1600x1200 (maximum)
 - (2) Geometry: No point in the active raster is to deviate from its correct position by more than 2 percent of raster height.

2.5.2.1 Mounting and Identification

- a. Mount monitors and other devices to facilitate easy replacement.
- b. The printed circuit board functions and component numbers or markings are to be easily read.
- c. Mount monitors in a desk top console.
- d. Protect monitors from circuit overloads by fuse or fuses in the power source line. Mount power source line fuses in finger-operated extractor fuse posts. Fuse holders are to be located in a readily accessible position.

2.5.2.2 Video and Signal Input

Monitors are to operate with video input requiring a one HDMI nominal composite video signal switchable to either loop-through or internal 75-ohm terminating impedance.

Signal input connectors must be HDMI type.

2.5.3 Ancillary Equipment

Equipment is to consist of the items specified below:

2.5.3.1 Video Date and Time Generator

The video time and date is to originate from either the camera, video, video recorder, or time server.

2.5.3.2 Camera Identifiers

Label video signal from each camera using alphanumeric identifiers. Camera alphanumeric identifiers may originate from either the camera or the video recorder.

2.5.3.3 Video Recording

2.5.3.3.1 Network Video Recorder (NVR)

- a. Provide NVR with an integral software ESS-CCTV server function. Dedicated **video surveillance** monitors and authorized computers networked to the NVR are to be capable of viewing recorded and live video from the network. The NVR is to be able to record and transmit video with up to 30 fps at maximum camera resolution. The NVR is to network with and utilize smaller, non-server computers at off-site camera locations as local recorders.
- b. Provide NVR with the capability to de-warp live and recorded images.
- c. The storage memory capacity of the NVR (including local recorders) is to be sufficient to store a minimum of 30 days of video at 15 fps, 2.1 megapixel resolution and be expandable for an increased capacity of **2** TB and be capable of including Redundant Array of Independent Disc (RAID) arrays 5.
- d. The NVR must have the capacity to address and process up to **4** dual-streaming cameras. The NVR must record all cameras onto a hard drive and allow remote network viewing via intranet browser. Hard drive capability must be sized to store all cameras recording 24 hours a day 7 days a week at 15 frames per second per camera for 4 weeks.

2.5.3.3.2 Video Recording Performance

The video recording performance is to be as follows:

- a. The NVR is to use modular hard disk media, with a digital format capacity of **1TB** per module.
- b. Provide a 4 channel triplex video multiplexer capable of performing encoding, recording and multiscreen viewing modes simultaneously. Provide 4 channels of live, simultaneous video images in which all channels are refreshed at **60** frames per second.
- c. Provide a 10-100Base-T connection for record review and camera view and control that is compatible for a PC workstation equipped with latest Microsoft Windows Professional operating system software, Internet Browser Software.

- d. PC workstation Viewing: Include direct access from the ESS PC workstations to each NVR via a Microsoft Internet Explorer Web Browser. All necessary descriptive bookmarks and shortcuts are to be prepared on each PC workstation to allow this direct access. All functions are to be accessible through HTML commands from a user's web browser interface. Pictures are to be available for attachment via a user-provided SMTP-based e-mail transport system, and included capability for 16 users and 3 user access levels (admin, control and user).
- e. Include sampling at 720(H) by 480(V) and 320(H) by 240(V) (Pixel Memory) with 60 frames per second and 3-D scan conversion to enable jitter-free stabilized pictures in a single frame. Modes include:
 - (1) Emergency
 - (2) Event
 - (3) Schedule
 - (4) Manual Recording
- f. Each camera is to support individual Recording Rate and Image Quality settings for each mode (Emergency, Event, Schedule and Manual Recording). This array of Camera Recording Rate and Image Quality settings by the Recording Modes is to form one of four Program Actions. The Program Action is to be assignable to a Time Table to form one of 16 Independent Recording Profiles. Allow each Recording Profile to be manually activated, activated via RS-232C interface, automatically activated by Time Table, or activated by separate alarm or emergency inputs.
- g. Digital display on the monitor and also recording of the following information to included:
 - (1) Year
 - (2) Month
 - (3) Day
 - (4) Hour
 - (5) Minute
 - (6) Second
 - (7) Alphanumeric camera location ID up to 8 characters. The NVR is to feature video loss detection on all channels.
- h. Pre-event recording: Buffer at least 20 seconds of pre-event pictures simultaneously for all individual camera channels.
- i. Motion-based Recording: Advanced integrated VMD is to be used to detect a specific area, direction and motion duration for each camera channel, independently and simultaneously. Motion Search may be executed for a single camera channel for a selected area on the image.
- j. Disk Partitioning: Provide within the NVR an automated disk

management and a RTOS (real-time operating system) platform to include a minimum of 4.8 TB of digital video storage on a single partition.

The video recording system is to provide a choice of Physical Partitioning as RAID 5 or Disk Mirroring redundant array recording. Allow the operator to be able to partition the available recording areas in a Virtual Partition by Regular, Event, and Copy Partitions. Manually and Scheduled recorded video information is to be assigned to a Regular Recording Partition, which may be overwritten. Event and Emergency Recording Data is to be assignable to an Event Partition, where image overwriting is prohibited. Any copied data is to be able to be assigned to the Copy Partition, which may be overwritten or saved as required.

- k. Playback: Permit direct camera selection for recording playback of any of 4 video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer capability).
- l. Multiplexer Functions: Include an integral, programmable switcher with programmable dwell time and camera order that automatically switches multiple camera images to enable sequential spot monitoring and simultaneous field recording. Provide switcher with separate spot, multiscreen, multiscreen-RGB, and cascaded video monitor outputs. The unit must have full screen, 4 multiscreen monitoring modes.
- m. Outputs
 - (1) Provide via BNC female connections 4 looping outputs for all video source connections to external monitoring systems including multiscreen and spot monitor video outputs.
 - (2) Provide via RCA phone jacks four channels of audio connection, including audio loop through.
 - (3) Provide via High Speed (480 Mbps) serial interface one External Storage connection.
 - (4) Provide via High Speed (480 Mbps) serial interface one External Copy connection.
 - (5) Provide two independent Video Outputs assignable to Multiscreen.
 - (6) Provide one Cascade output for connecting 3 additional digital video recorders for centralized control using a single video monitor.
 - (7) Provide virtual camera number programming capability to support 64 camera channels on a single system.
 - (8) Provide one independent RGB Video output, capable of monitoring all DVR functions.
- n. All camera selection buttons are to have Tri-State Indication, corresponding to Recording, Viewing and Control functions on actual NVR hardware. PC emulation is not an acceptable alternative. Furnish the following indicators:
 - (1) Alarm

- (2) Alarm Suspend
 - (3) Operate
 - (4) HDD1, Hard drive identifier
 - (5) Timer and Error indicators
 - (6) Camera Selection
 - (7) Iris
 - (8) Preset
 - (9) Camera Automatic Mode
 - (10) Pan-Tilt
 - (11) Set
 - (12) Jog Dial
 - (13) Shuttle Dial
 - (14) Setup-Esc
 - (15) Record
 - (16) Search
 - (17) Play-Pause
 - (18) Pan-Tilt Slow
 - (19) Stop
 - (20) Pan-Tilt Go to Last
 - (21) Zoom-Focus
 - (22) A-B
 - (23) Repeat
 - (24) Shift
 - (25) Alarm Reset Buttons
- o. Networking: All NVR recording, review, playback, camera control and setup are to be available via the internally mounted Network Interface. A 10-100Base-T connection for record review and camera view and control will be required on a personal computer equipped with Internet Browser Software and an Ethernet 100Base-T connection. Permit direct camera selection for recording playback of any of 4 video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer mode). Support a minimum of 8 simultaneous clients viewing and 2 simultaneous FTP sessions.

- p. Power: The video recording equipment must have a power source of 120 VAC at 60 Hz.

2.5.3.4 Camera Control

Provide access to camera functions and control for all cameras via the multiplexer for all camera control, set-up and alarm functions, including preset sequence, digital motion detector mask set, and back light compensation set-up. Controllable camera functions are to be accessible via front panel controls or the optional system controller. These functions are to include:

- (1) Direct access of preset position
- (2) Zoom (near/far)
- (3) Focus (near/far)
- (4) Iris (open/close)
- (5) Pan (left/right)

2.5.4 Camera Mounting Structures

Provide camera mounting structures designed specifically for IP video surveillance cameras. The structure is to accommodate appropriate wiring pathways for power and communication as well as proper grounding and surge protection. Design loads for the camera mounting structure must conform to TIA-222 and all applicable addendums of the TIA standard.

2.6 SECURITY COMMAND CENTER (SCC)

The SCC must incorporate all ACS and IP Video Surveillance System subsystems and communications, and provide operator control interface to the ESS system. The components are as follows:

- a. ESS Software
- b. Monitoring Display Software
- c. Graphical Map Software
- d. Printers
- e. Controls and Display Integration
- f. Enrollment Center Equipment
- g. Workstation Computer

2.6.1 ESS Software

- a. Provide commercial off-the-shelf ESS software that utilizes a single database for each subsystem. The system is to archive all events in a database stored either on a local hard drive or a networked database server. The software has to support configuration and simultaneous monitoring of all subsystems.
- b. Allow the networked PC workstation configurations connected via a

dedicated ESS TCP/IP network. Administrative tasks including configuration, monitoring, schedules, report generation and graphic display are provided from any PC workstation on the network. All system programming data must be instantly accessible to every PC Workstation connected to the ESS network. The system is to utilize a non-proprietary SQL-based, ODBC-compliant database, managed by Sybase Adaptive Server Anywhere, Microsoft SQL Server, or Oracle.

- c. Utilize a preemptive multi-tasking operating system, such as the latest Microsoft Windows Professional environment, that is multitasking, with many processes running at the same time without interference with each other and with higher priority tasks taking precedence over lower priority tasks.
- d. Provide capabilities to define visual exclusion areas.

2.6.1.1 Alarm Call up

Support responses to alarms entering the system with each alarm capable of initiating one or more of the following actions:

- a. Sending alarm commands to a IP Video Surveillance system interface
- b. Activating output devices
- c. Playing PC audio files
- d. Controlling doors
- e. Display graphical maps associated with the alarm device

Provide mode of system operation that requires an operator to acknowledge any alarm. While alarm is still active, the alarm cannot be cleared.

2.6.1.2 Programming

Provide the capability of, but not limited to, the following programming and functionality:

2.6.1.2.1 Daylight Savings Time Adjustment

The ACU(s) and PCU(s) must not need to be connected to the ESS in order for the adjustment to occur.

2.6.1.2.2 Operator Privileges

Support an unlimited number of system operators, each with a unique login and password combination. Operators are to be assigned privileges based on the loops, commands, or programming features that are available to each individual operator.

2.6.1.2.3 Alarm Priorities

Provide the ability for each alarm device to be user configured to belong to one of 10,000 priority levels which are assigned to an alarm based on alarm importance. These priorities are to define which alarm events to display on individually specified ESS workstations.

2.6.1.2.4 Reports

Include reporting capabilities as well as the ability to run Crystal Report templates.

2.6.1.2.5 User Interface

The ESS programming is to be menu-driven, with "wizards" to assist with software configuration, and include 'Help' information.

2.6.1.2.6 Messages

Permit the use of user-selected colors for event messages.

2.6.1.2.7 Graphics

Provide the capability to display a floor-plan graphic for card activity and alarm events.

2.6.1.2.8 Device Status

Provide the capability to display the dynamic status of a user-selected list of devices, including doors, inputs, and outputs.

2.6.1.2.9 Diagnostics

Include diagnostic software tools that interface and query the hardware for information and to issue commands.

2.6.1.2.10 Mandatory Data Fields

Require any cardholder data field to be selected by the user as mandatory.

2.6.1.2.11 User Defined Data Fields

Provide 20 unassigned data fields for storing user-defined data that support user-defined labels, and are user-configurable as plain text fields or drop-down selection lists.

2.6.1.2.12 Archive Database

Include a connection to an archive database which stores purged events and deleted programming and which can be accessed for reporting.

2.6.1.2.13 Programmable Database Backup

Include the capability of performing user-scheduled database backups without the use of third-party backup software.

2.6.1.2.14 Programmable Database Purging

Include the capability of performing user-scheduled database purging, moving selected events to an archive database when the events have aged a user-specified number of days.

2.6.1.2.15 Database Importing

Include the capacity to import user data from an ODBC data source (Access, Excel, text).

2.6.1.2.16 Data Exporting

Include the capacity to export data from any table in the database to either a text, HTML, Excel, or Access file in any user-selected order.

2.6.1.2.17 Event Log Output

Include the capacity to send a continuous stream of user-selected types of event messages to a text file, serial port, or TCP/IP address.

2.6.1.2.18 Data Audit Trail

Record changes to programming, recording the date and time stamp of the change, the name of the operator making the change, and the nature of the change. This data audit is to be available in history for reporting.

2.6.2 ESS Monitor Display Software

ESS Monitor display software is to provide for text and graphic map displays that include zone and device status integrated into the display. Different colors are to be used for the various components and real time data. Colors must be uniform on all displays. Follow the color coding as follows.

- a. FLASHING RED to alert an operator that a zone has gone into an alarm or that primary power has failed.
- b. RED to alert an operator that a zone is in alarm and that the alarm has been acknowledged.
- c. YELLOW to advise an operator that a zone is in access.
- d. GREEN to indicate that a zone is secure or that power is on.

2.6.3 Graphical Map Software

- a. ESS graphical map software is to show the graphic and visual data of all subsystem devices. Use a 19 inches, LED flat screen display with messages displayed in the English language. Provide graphical maps showing a layout of all the protected facilities. Highlight zones corresponding to those monitored by the ESS on the graphical maps. Display status of each zone using graphical icons as required within each designated zone.
- b. Provide capability for graphical maps to be linked together using a layered tree structure. For example, a top-level map might be a top view of the site and its buildings, the next level the individual buildings floor, followed by a map of the area on a floor containing the device in alarm. Allow for 3 layers of maps to be defined for any given ESS device. To speed an incident location, each map level contains a clearly visible indicator as to which sub map the operator should select next to find the device that is in alarm.
- c. The ESS may also be configured to display a map automatically on a new alarm presentation, providing the operator with prompt visual indication that an alarm has occurred.
- d. The status of intrusion devices, access control readers, doors,

auxiliary monitor points, and auxiliary outputs is to be able to be requested from any map by simply selecting the icon representing the device and its current state will be displayed. **IP video surveillance** camera control, digital video review, alarm panel transactions and intercom requests are to be available for inclusion on the map with the associated management module installed.

- e. Allow for SCC operators to change a current setting by pressing the right mouse button anywhere on the screen or on a specific system device icon. Pressing the right mouse button is to cause the appropriate command options list to appear for selection. Confirmation is provided by reflecting the change in status on the display after a command is selected.
- f. The display of intrusion or auxiliary door alarms may be automatically enabled or disabled by the use of timed commands, either by device or by a group of devices. This may be used, for example, to disable all door alarms on internal doors, during normal office hours.
- g. Create maps using standard office tools allowing drawings to be imported in Jpeg, Bitmap, Windows metafile, PDF or DXF file formats to provide maximum flexibility.

2.6.4 Printers

2.6.4.1 Report Printer

Provide a laser text printer to generate reports that is a USB interface dry-type laser process printer. Provide a printer with the capability of holding a minimum of 500 pages. The unit must print a minimum of 30 pages per minute at 600 dpi resolution.

2.6.4.2 Alarm Printer

Provide an alarm printer interconnected to the SCC equipment with a minimum print rate of 30 characters per second to produce hard copy of system events. Printer meet requirements per paragraph REPORT PRINTER.

2.6.5 Control and Display Integration

Integrate human engineer SCC controls so the entire SCC can be operated by a single or multiple operator(s). Integrate switching and monitoring components of the assessment subsystem with the SCC so that SCC operator(s) can effectively monitor, assess alarms and control the ESS. Method of system integration must be as a single console. Provide chassis, and modules required for console SCC configuration.

2.6.6 Enrollment Center Equipment

Provide enrollment stations to enroll personnel into, and disenroll personnel from, the system database. The enrollment equipment is to only be accessible to authorized entry control enrollment personnel. **The enrollment center will be compatible with GFGI "CAC" cards.** The enrollment equipment is to include subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the SCC. Provide a printer for the enrollment station which meets the requirements of paragraph "Report Printer.

2.6.6.1 Enrollment Center Accessories

- a. Provide a steel desk-type console and equipment racks. The console is to be as specified in ECIA EIA/ECA 310-E and as indicated.
- b. Rack-mount all equipment in the console and equipment racks, except for printer. Color coordinate the console and equipment racks and cabinets, obtaining approved by the Contracting Officer.
- c. Provide a locking cabinet approximately 6 feet high, 3 feet wide, and 2 feet deep with three adjustable shelves, and two storage racks for storage of CDs, DVDs, printouts, printer paper, ink/toner, manuals, and other documentation.

2.6.6.2 Enrollment Center Software

Provide database management functions for the system, and allow an operator to change and modify the data entered in the system as needed. The enrollment station is not to have any alarm response or acknowledgment functions as a programmable system function. Multiple, password-protected access levels are to be provided at the enrollment station. Database management and modification functions are to require a higher operator access level than personnel enrollment functions. Provide a means for disabling the enrollment station when it is unattended to prevent unauthorized use.

Provide a method to enter personnel identifying information into the entry control database files through enrollment stations to include a credential unit in use at the installation. In the case of personnel identity verification subsystems, this data is to include biometric data. Allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names is to be customized to suit user and site needs. All personnel identity verification subsystems selected for use with the system are to fully support the enrollment function and be compatible with the entry control database files.

2.6.7 Workstation Computer

Provide a standard desktop computer or a laptop with the latest Microsoft Windows Professional operating system software meeting the following minimum requirements:

2.6.7.1 Processor

Quad-core processor designed for desktop or laptop applications. Processor speed must be at least 50 percent of the speed of the fastest Intel laptop processor commercially available.

2.6.7.2 Random Access Memory (RAM)

300 percent of the recommended requirements of the software to be installed on the computer and no less than 8GB.

2.6.7.3 Communications Ports

Three USB ports, Dual Thunderbolt ports for charging.

2.6.7.4 Hard Drive and Controller

1 TB or larger solid state drive.

2.6.7.5 Video Output

32-bit color with a minimum resolution of 1920 by 1080 at minimum refresh rates of 70 Hz and HDMI output.

2.6.7.6 Keyboard and Smart Card Reader

101 key wired USB keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154 or standard laptop keyboard and an integral smart card reader compatible with a Department of Defense Common Access Card (CAC).

2.6.7.7 Mouse

2-button wired USB optical scroll mouse with a minimum resolution of 400 dots per inch.

2.7 COMMUNICATIONS

- a. Communications are to link together subsystems of the ESS and be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Interfaces between subsystems cannot be accomplished by use of an electro-mechanical relay assembly. Communications links must be supervised. Provide common communications interface devices throughout the ESS. Provide dry contact sensor to control unit interface that is normally OPEN or normally CLOSED, except as specified otherwise.
- b. Use digital, asynchronous, or multiplexed data control unit for central alarm reporting and display processor interface. Group individual data bits into word format and transmit as coded messages. Implement interface with network switches which function as a communications controller, perform data acquisition and distribution, buffering message handling, error checking, and signal regeneration as required to maintain communications.
- c. Provide totally automatic status changes communication, commands, field initiated interrupts, and any other communications required for proper system operation. Do not require system communication operator initiation or response. System communication is to return to normal after any partial or total network interruption including power loss or transient upset. Automatically annunciate communication failures to the operator with communication link identification that has experienced a partial or total failure.

2.7.1 Link Supervision

2.7.1.1 Hardwire Direct Current Line Supervision

Provide only for the sensor to control unit links which are within the ESS protected area. Supervise circuits by monitoring changes in the current that flows through the detection circuit and a terminating resistor of at least 2.2 K ohms. Supervision circuitry is to initiate an alarm in response to opening, closing, shorting, or grounding of conductors by employing Class C standard line security. Class C circuit supervisor

units are to provide an alarm response in the annunciator in not more than one second as a result of the following changes in normal transmission line current:

- a. Five percent or more in normal line signal when it consists of direct current from 0.5 through 30 milliamperes.
- b. Ten percent or more in normal line signal when it consists of direct current from 10 microamperes to 0.5 milliamperes.
- c. Five percent or more of an element or elements of a complex signal upon which security integrity of the system is dependent. This tolerance will be applied for frequencies up to 100 Hz.
- d. Fifteen percent or more of an element or elements of a complex signal upon which the security integrity of the system is dependent. This tolerance will be applicable for all frequencies above 100 Hz.

2.7.1.2 Hardwire Alternating Current Supervision

Supervision is not to be capable of compromise by use of resistance, voltage, or current substitution techniques. Use this method on circuits which employ a tone modulated frequency-shift keying (FSK), interrogate-and-reply communications method. Supervisory circuit are to be immune to transmission line noise, crosstalk, and transients. Terminate detection circuit by complex impedance. Maintain line supervision by monitoring current amplitude and phase. Size complex impedance so that current leads or lags the driving voltage by 45 plus or minus 5 degrees.

Alarm when rms current changes by more than 5 percent, or phase changes by more than 5 degrees for supervision current of 0.5 to 30 milliamperes rms. Alarm when rms current changes by more than 10 percent, or phase changes by more than 8 degrees for lines with supervision currents of 0.01 to 0.5 milliamperes. Identified line supervision alarm must be communicated within one second of the alarm.

2.7.1.3 Hardwire Digital Supervision

Local processors are to exchange digital data to indicate secure or alarm at least every 2 seconds. Alarm if data is missed for more than one second for passive supervisory circuits. Coding used for data cannot be decipherable by merely viewing data on an oscilloscope. Supervisory circuits are to asynchronously transmit bursts of digital data for transponder schemes. Data pattern is to be random in nature. Remote detectors are to receive data and encode a response based on a proprietary coding scheme.

Provide a unique encoding scheme; Transmit encoded response back to supervisory circuit. Supervisory circuit is to compare the response to an anticipated response. Alarm on failure of the detector to return a data burst or return an incorrect response.

2.7.2 Hardwire

2.7.2.1 Electrical Conductor Lines

- a. Use electrical conductor lines for hardwire that rely on current path except for electrical wires; neutral conductors of electrical

distribution systems cannot be used as signal transmitters.

- b. Conductors outside the protected area are to be installed in electrical metallic tubing (EMT) as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Supervision circuitry is not to initiate nuisance alarms in response to normal line noise, transients, crosstalk, or in response to normal parametric changes in the line over a temperature range of minus 30 to 125 degrees F.
- c. Ambient current levels chosen for line supervision must be sufficient to detect tampering and be within the normal operating range of electrical components. Report line supervision and tamper alarms regardless of mode of operation.
- d. Provide hardwire links as specified in UL 1076 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM for interior applications with additions and modifications specified. Conductors are to be copper. Conductors for links which also carry AC voltage, are to be No. 12 AWG minimum; single conductors for low-voltage DC links are to be No. 14 AWG minimum. Conductors are to be color coded. Conceal wiring in finished areas of new construction and wherever practical in existing construction if not otherwise precluded by the Government.
- e. Identify conductors within each enclosure where a tap, splice, or termination is made. Identify conductors by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Connect sensors, control units, and communication devices so that removal will cause a tamper alarm to sound. Pigtail or "T" tap connections are not acceptable. Each conductor used for identical functions is to be distinctively color-coded. Each circuit color-coded wire is to remain uniform throughout circuit. Tamper switches meet requirements of paragraph TAMPER SWITCHES.

2.7.2.2 Communication Link

- a. Provide a dedicated circuit communication link from sensor to control unit. Opening or closing a relay contact will indicate an alarm. Convert analog signals to digital values or a relay closure or opening within 250 feet of the sensing point. Communications from control unit to central alarm reporting and display processor are to operate in a continuous interrogation and response mode, using time-multiplexed digital communications techniques at a data rate of 5.12 kilobaud.
- b. Interrogation and response communications between the control unit and central processor is to be half-duplex and bidirectional on one dual twisted pair cable (one pair for interrogation and one for response), which may have one or more parallel branches. Individual control unit lines are to be at least 22 AWG wire. Connect control wires in parallel to the hardwire link. Communication system is to provide as many as 255 control unit connections.
- c. The communication system must maintain specified performance over a link length of 7500 feet when operating without line repeaters or other signal regenerating or amplifying devices. The communications system must maintain specified performance over a link length of 75,000 feet when operating with signal-regenerating line repeaters.
- d. Control unit to central alarm reporting and display processor

communications link is to also be capable of operating over a maximum of two standard voice grade telephone leased or proprietary lines. Link is to be capable of operating half duplex over a Type 3002 data transmission pair and be capable of modular expansion. Telephone lines will be provided by the Government. Coordinate and check out system operation. General characteristics and telephone line service are to be as follows:

Connections	Two- or four-wire
Impedance at 1000 Hz	600 ohms
Transmitting level	0 to 12 dBm
Transmitting level adjustment	3 dB increments
Type	Data
Direction	Two-way alternate (half duplex)
Maximum speed	1.2 kilobaud
Maximum loss at 1000 Hz	33 dB

2.7.3 Network Switch

The small form-factor pluggable (SFP) is to provide full-duplex 1000/100/10-Mbps connectivity between switches over single mode (SM) infrastructures. Provide mounting accessories for a typical rack. Rack requirements as specified in paragraph EQUIPMENT RACK.

2.7.3.1 Inside Plant

Provide a network switch for ESS system with 8 SFP Ethernet ports. Allow dynamic port base security and rapid spanning tree protocol with VLAN assignments for specific users regardless of where the switch is connected. The switch will use AC input voltage nominal of 120 VAC at 60 Hz. The switch is to be less than 2 Rack Units (RU) and Layer 3 capable. The switch is to have the capability of commanding a self-healing ring configuration. 1000Base-LX SFP Fast Ethernet Interface Converter is to be a hot swappable device that plugs into a Gigabit fiber SFP uplink port on the switch. The switch is to be a fully managed power over Ethernet (PoE) to all ports. Provide switch capable of using a Layer 3 (routed) port to connect to a LAN gateway port for Internet and web base access. The Mean Time Between Failure (MTBF) must be greater than 210,000 hours.

2.7.4 Video and ESS Transmission

Video and ESS transmission cables must conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

Install interior cable in Electrical Metallic Tubing (EMT) conduit unless indicated otherwise. Cable is to be rated for the installation method intended.

2.7.5 Wire and Cable

Provide all wire and cable not indicated as Government-furnished equipment. Wiring must meet NFPA 70 standards and as indicated in the Wire and Cable Data Sheets Attachment at the end of this section.

2.7.6 Digital Data Interconnection Wiring

Interconnecting cables carrying digital data between equipment located at the SCC or at a secondary control and monitoring site is to be optical fiber cable. Interconnecting cables conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.7.7 Local Area Network (LAN) Cabling

Cabling must be in accordance with TIA-568.2, Category 6.

2.7.8 Cable Construction

Provide all cable components that will withstand the environment in which the cable is installed for a minimum of 20 years.

2.8 BACKUP POWER

- a. Intrusion alarms are not to be generated as a result of power switching; however, Provide a power switching indication and on-line source at the alarm monitor.
- b. The system is to automatically switch back to the primary source upon primary power restoration. Detect and report failure of an on-line battery as a fault condition. Power products must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.
- c. Provide backup power to the primary power by backup batteries in each element or subsystem or uninterruptible power supply (UPS).

2.8.1 Uninterruptible Power Supply (UPS)

Backup power for rack-mounted equipment is to be provided by a UPS. Provide 5 kVA, 1.0 PF, UPS with 208V, 3-phase input with NEMA L60-P plug. The UPS must have 12 NEMA 5-20R receptacles for output. The UPS must have 2U form factor in a standard 19" telecommunications rack.

Size the battery to sustain the UPS at full rated load for for 15 minutes.

2.8.2 Batteries

Provide backup by dedicated batteries in remotely located system elements including individual sensors or control units. Batteries are to be an integral part of dispersed system elements when radio frequency (RF) operation is required. Batteries are to be capable of operation in any position and be protected against venting caustic chemicals or fumes within an equipment cabinet. Provide batteries capable of continuous operation for up to 8 hours without recharge or replacement.

2.9 COMPONENT ENCLOSURE

Alarm enclosures with a tamper switch(es). Refer to paragraph "Tamper Switch". Enclosures is to be formed and assembled to be sturdy and

rigid. These include:

- a. Consoles
- b. Annunciator housings
- c. Power supply enclosures
- d. Sensor control and terminal cabinets
- e. Control units
- f. Wiring gutters
- g. Other component housings

2.9.1 Interior Sensor

Provide sensors to be used in an interior environment with a housing that provides protection against dust, falling dirt, and dripping noncorrosive liquids. Refer to paragraph "Interior Enclosures" for enclosure ratings.

2.9.2 Interior Enclosures

Enclosures to house equipment in an interior environment must meet the requirements of [NEMA 250](#) Type 1.

2.9.3 Metal Thickness

Thicknesses of metal in cast and sheet metal enclosures of all types must be not less than those listed in Tables 8.1, 8.2, and 8.3 of [UL 1610](#) for alarm components, and [NEMA ICS 2](#) and [NEMA ICS 6](#) for other enclosures. Sheet steel used in enclosure fabrication is to be at least 16 gage; consoles are to be at least 18 gage.

2.9.4 Doors and Covers

- a. Doors and covers are to be flanged. Provide tight pin hinges or the ends of hinge pins are to be tack welded to prevent ready removal where doors are mounted on hinges with exposed pins.
- b. Provide doors having a latch edge length of less than [24 inches](#) with a single lock. Provide the door with a three-point latching device with lock where latch edge of a hinged door is [24 inches](#) or more in length; or alternatively with two locks, one located near each end.
- c. The covers of provided junction boxes to facilitate initial system installation are to be held in place by tack welding, brazing, or one-way screws.

2.9.5 Ventilation

Ventilation openings in enclosures and cabinets must conform to requirements of [UL 1610](#).

2.9.6 Mounting

Sheet metal enclosures are to be rated for wall mounting with top hole slotted, unless otherwise indicated. Mounting holes are to be in

positions which remain accessible when major operating components are in place and door is open, and be inaccessible when door is closed.

2.9.7 Labels

Label boxes containing connections that they contain ESS connections and indicate that the box is part of the ESS system.

2.9.8 Test Points

Provide readily visible and accessible with minimum disassembly of equipment to test points, controls, and other adjustments inside enclosures. Test points and other maintenance controls must be readily accessible to operator personnel.

2.10 EQUIPMENT RACK

Provide standard 19 inch electronic rack cabinets conforming to UL 50 for the ESS system at the SCC and remote control and monitoring sites as shown on the drawings. Equipment rack must be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.10.1 Labels

Provide a labeling system for cabling as required by TIA-606 and UL 969. Provide stenciled lettering for voice and data circuits using laser printer.

2.11 LOCKS AND KEY LOCK

2.11.1 Lock

Provide locks on system enclosures for maintenance purposes that meet UL 437. Keys must be stamped "U.S. GOVT. DO NOT DUP.". Keys are only to be withdrawn when in the locked position. Key all maintenance locks alike and furnish only two keys for all of these locks.

2.11.2 Key-Lock Operated Switches

All key-lock-operated switches required to be installed on system components are to be UL 437. Keys must be stamped "U.S. GOVT. DO NOT DUP.". Key-lock-operated switches are to have two positions, with the key removable in either position. Key all key-lock-operated switches differently and furnish only two keys for each key-lock-operated-switch.

2.11.3 Construction Locks

Use a set of temporary locks during installation and construction. Do not include any of the temporary locks in the final set of locks installed and delivered to the Government.

2.12 FACTORY APPLIED FINISH

Electrical equipment is to have factory-applied painting systems which meets the requirements of the NEMA 250 corrosion-resistance test as a minimum.

PART 3 EXECUTION

3.1 INSTALLATION

Install the system in accordance with safety and technical standards [NFPA 70](#), [UL 681](#), [UL 1037](#), and [UL 1076](#). Configure components within the system with appropriate service points to pinpoint system trouble in less than 20 minutes.

Install all system components, including any equipment that is furnished by the Government, and appurtenances in accordance with the manufacturer's instructions, [IEEE C2](#) and as shown on the drawings, and furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

3.1.1 Existing Equipment

Connect to and utilize existing equipment, control signal transmission lines, and devices as shown on the drawings. Any equipment and signal lines that are usable in their original configuration without modification may be reused with Government approval.

Make written requests and obtain approval prior to disconnecting any signal lines and equipment that creates equipment outage. Such work can proceed only after receiving Government approval of these requests. If any device fails after work has commenced on that device, signal, or control line, diagnose the failure and perform any necessary corrections to the equipment. The Government is responsible for maintenance and repair of Government equipment. The Contractor will be held responsible for repair costs due to negligence or abuse of Government equipment on their part.

3.1.2 Software Installation

Load software as specified and required for an operational system, including databases and specified programs. Provide original and backup copies on optic discs of all accepted software, including diagnostics, upon successful endurance test completion.

3.1.3 Enclosure Penetrations

Enclosures are to be penetrated from the bottom unless shown otherwise. Penetrations of interior enclosures having transitions of conduit from interior to exterior, and penetrations of exterior enclosures are to be sealed with rubber silicone sealant to preclude the entry of water. Terminate conduit risers in a hot-dipped galvanized metal cable terminator that is filled with a sealant as recommended by the cable manufacturer, and in a manner that does not damage the cable.

3.1.4 Cable and Wire Runs

Perform required cable and wire routings per [NFPA 70](#) and Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM and as specified. Terminate conduits including flexible metal and armored cable in the sensor or device enclosure. Fit ends of conduit with insulated bushings. Exposed conductors at ends of conduits external to sensors and devices are not acceptable.

3.1.5 Soldering

Soldered electrical connections must use composition Sn60, Type AR or S, for general purposes; use composition Sn62 or Sn63, Type AR or S, for special purposes. Flux must conform to [ASTM B32](#) when Type S solder is used for soldering electrical connections.

3.1.6 Galvanizing

Ferrous metal is to be hot-dip galvanized in accordance with [ASTM A123/A123M](#). Provide screws, bolts, nuts, and other fastenings and supports that are corrosion resistant.

Field welds or brazing on factory galvanized boxes, enclosures, conduits, and so on, are to be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

3.1.7 Conduits

Install interior conduits in accordance with [NFPA 70](#), Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.8 Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting must be as specified in Section [09 90 00](#) PAINTS AND COATINGS.

3.2 ADJUSTMENT, ALIGNMENT, SYNCHRONIZATION, AND CLEANING

- a. Clean each system component of dust, dirt, grease, or oil incurred during and after installation or accrued subsequent to installation from other project activities subsequent to installation.
- b. Prepare for system activation by manufacturer's recommended procedures for adjustment, alignment, or synchronization.
- c. Prepare each component in accordance with appropriate provisions of component installation, operations, and maintenance manuals.
- d. Remove large vegetation that may sway in the wind and touch fencing.
- e. Adjust sensors so that coverage is maximized without mutual interference.

3.3 SYSTEM STARTUP

Do not apply power to the system until after:

- a. Set up system equipment items and communications in accordance with manufacturer's instructions.
- b. Conduct a system visual inspection to ensure that defective equipment items have not been installed and that there are no loose connections.
- c. Test and verify system wiring as correctly connected.
- d. Verify system grounding and transient protection systems as properly installed.

- e. Verify the correct voltage, phasing, and frequency of the system power supplies.

Satisfaction of the requirements above does not relieve the contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as result of Contractor work or equipment.

3.4 SUPPLEMENTAL CONTRACTOR QUALITY CONTROL

Provide the services of technical representatives who are familiar with all components and installation procedures of the installed system; and are approved by the Contracting Officer. These representatives are to be present on the job site during the preparatory and initial phases of quality control to provide technical assistance. These representatives are also to be available on an as needed basis to provide assistance with follow-up phases of quality control. These technical representatives are to participate in the system testing and validation and provide certification that their respective system portions meet the contractual requirements.

The above requirements supplement the quality control requirements specified elsewhere in the contract.

3.5 ESS SYSTEM TESTING

All ESS Testing requirements are specified in Section 28 08 10 ELECTRICAL SECURITY SYSTEM ACCEPTANCE TESTING.

3.6 ESS TRAINING

Conduct training courses for 10 designated personnel in system maintenance and operation. Coordinate training with the Government. The training is to be oriented to the specific system being installed. Training content is to include training manuals and audio-visual materials. Deliver training manuals for each trainee with 2 additional copies delivered for archiving at the project site. The manuals are to include an agenda, defined objectives for each lesson, and a detailed subject matter description for each lesson.

Furnish audio-visual equipment and other training materials and supplies. Deliver copies of the audio-visual materials to the Government either as a part of the printed training manuals or on the same media as that used during the training sessions when course portions are presented using audio-visual material.

3.6.1 ESS Training Outline

Submit a training plan for the training phases, including type of training to be provided, outline of training manuals, training course agendas, and a list of reference material, for Government approval.

3.6.2 Typical Training Day

A training day is defined as:

- a. Eight hours of classroom instruction, with
 - (1) Two 15-minute breaks

(2) One hour lunch break

b. Conducted:

(1) Monday through Friday

(2) During the daytime shift in effect at a Government-provided training facility

For guidance in planning the required instruction, assume that attendees will have a high school education or equivalent, and are familiar with ESS. Approval of the planned training schedule is to be obtained from the Government at least 30 days prior to the training.

3.6.3 ESS Administrator Training

a. ACS and IDS Administrator Training includes:

- (1) Two eight-hour on-site training sessions
- (2) Operating system procedures and configuration
- (3) Operator functions
- (4) Database functions and setup
- (5) Card holder input and deletion procedures
- (6) Report generation
- (7) Applications programs (as applicable)
- (8) Graphics generation and manipulation
- (9) Items unique to the ACS and IDS interfaces with other systems
- (10) System backup and restore

b. **IP Video Surveillance** System Administrator Training includes:

- (1) One eight-hour session on site
- (2) Training is to include all administrator and operator functions, and items unique to the installed **IP Video Surveillance** System, and interfaces with other systems.

3.6.4 ESS Operator Training

Coordinate the operator training syllabus with the Government prior to conducting operator training.

a. ACS and IDS Operator Training includes:

- (1) Four (one-day) 8 hour on-site training sessions
- (2) System operating procedures
- (3) System configuration orientation

- (4) Alarm acknowledgment
- (5) Alarm response logging
- (6) Graphics functionality
- (7) Items unique to the ACS and IDS interfaces with other systems

b. **IP Video Surveillance** Operator Training includes:

- (1) Two (one-day) 8 hour on-site training sessions
- (2) System operating procedures
- (3) System configuration
- (4) Video call-up
- (5) Camera and monitor control
- (6) Graphics functionality
- (7) Basic device terminology and troubleshooting

3.6.5 Maintenance Personnel Training

The system maintenance course is to be taught at the project site after endurance test completion for a period of five training days. A maximum of five personnel, designated by the Government, will attend the course. The training includes:

- a. Physical layout of each piece of hardware.
- b. Troubleshooting and diagnostics procedures.
- c. Component repair and replacement procedures.
- d. Maintenance procedures and schedules to include system testing after repair.
- e. Calibration procedures. Upon course completion, the students are to be proficient in system maintenance.
- f. Review of site-specific drawing package, device location, communication, topology, and flow.

3.6.6 Follow-up Training

- a. Provide One hour training session each month for two months after initial training.
- b. Follow-up training is to begin one month after initial training.
- c. Training is to include testing for system competence.

3.7 NAMEPLATE MOUNTING

Provide nameplate number, location, and letter designation as indicated.

Fasten nameplates to the device with a minimum of two sheet-metal screws or rivets.

-- End of Section --

SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE

PART 1 GENERAL

1.1 REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2 (2020) American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

FM GLOBAL (FM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 4 (2018) Standard for Integrated Fire Protection and Life Safety System Testing

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National Electrical Code

NFPA 72 (2022; ERTA 22-1) National Fire Alarm and Signaling Code

NFPA 90A (2024) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 170 (2021) Standard for Fire Safety and Emergency Symbols

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-601-02 (2021) Fire Protection Systems Inspection, Testing, and Maintenance

UFC 4-010-06 (2016; with Change 1, 2017) Cybersecurity of Facility-Related Control Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

- 47 CFR 15 Radio Frequency Devices
- 47 CFR 90 Private Land Mobile Radio Services

UNDERWRITERS LABORATORIES (UL)

- UL 268 (2016; Reprint Nov 2021) UL Standard for Safety Smoke Detectors for Fire Alarm Systems
- UL 268A (2008; Reprint Oct 2014) Smoke Detectors for Duct Application
- UL 464 (2016; Reprint Sep 2017) UL Standard for Safety Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
- UL 497A (2001; Bul. 2019) UL Standard for Safety Secondary Protectors for Communications Circuits
- UL 497B (2004; Reprint Feb 2022) UL Standard for Safety Protectors for Data Communications and Fire Alarm Circuits
- UL 864 (2014; Reprint May 2020) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
- UL 1283 (2017) UL Standard for Safety Electromagnetic Interference Filters
- UL 1449 (2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
- UL 1480 (2016; Reprint Sep 2017) UL Standard for Safety Speakers for Fire Alarm and Signaling Systems, Including Accessories
- UL 1638 (2016; Reprint Sep 2017) UL Standard for Safety Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
- UL 1971 (2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
- UL 2017 (2008; Reprint Dec 2018) UL Standard for Safety General-Purpose Signaling Devices and Systems
- UL 2034 (2017; Reprint Sep 2018) UL Standard for Safety Single and Multiple Station Carbon Monoxide Alarms

UL 2075	(2013; Bul. 2019) UL Standard for Safety Gas and Vapor Detectors and Sensors
UL 2572	(2016; Bul. 2018) UL Standard for Safety Mass Notification Systems
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 RELATED SECTIONS

Section 25 05 11 Cybersecurity for Facility-Related Control Systems, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 21 13 13 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
Section 21 30 00 FIRE PUMPS
Section 23 30 00 HVAC AIR DISTRIBUTION
Section 08 71 00 DOOR HARDWARE
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.3 SUMMARY

1.3.1 Scope

- a. This work includes designing and providing a new, complete, fire alarm and mass notification (MNS) system as described herein and on the contract drawings for the project. Include system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, initiating devices, notification appliances, supervising station fire alarm transmitters/mass notification transceiver, and other accessories and miscellaneous items required for a complete operational system even though each item is not specifically mentioned or described. Provide asystems complete and ready for operation. Cybersecurity design and installation must comply with UFGS 25 05 11, UFC 4-010-06 and AFGM 2019-320-02.
- b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with NFPA 72, except as modified herein. The system layout on the drawings show the intent of coverage and suggested locations of devices. Final quantity, system layout, and coordination are the responsibility of the Contractor.
- c. Where a fire pump is provided, the fire alarm and mass notification system must monitor and transmit the fire pump controller signals in accordance with the provisions of NFPA 72.
- d. The fire alarm and mass notification system must be independent of the building security, building management, and energy/utility monitoring systems other than for control functions.

1.3.2 Qualified Fire Protection Engineer (QFPE)

Services of the QFPE must include:

- a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Construction (shop) drawings and calculations must be prepared by, or

prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.

- b. Providing a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting any outstanding comments.
- c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).
- d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.
- e. Signing applicable certificates under SD-07.

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions must be defined as follows:

1.4.1 Interface Device

An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

1.4.2 Fire Alarm and Mass Notification Control Unit (FMCU)

A master control unit having the features of a fire alarm control unit (FACU) and an autonomous control unit (ACU) where these units are interconnected to function as a combined fire alarm/mass notification system. The FACU and ACU functions may be contained in a single cabinet or in independent, interconnected, and co-located cabinets.

1.4.3 Remote Fire Alarm and Mass Notification Control Unit

A control unit, physically remote from the fire alarm and mass notification control unit, that receives inputs from automatic and manual fire alarm devices; may supply power to detection devices and interface devices; may provide transfer of power to the notification appliances; may provide transfer of condition to relays or devices connected to the control unit; and reports to and receives signals from the fire alarm and mass notification control unit.

1.4.4 Local Operating Console (LOC)

A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery of recorded messages and/or live voice announcements, initiate visual, textual visual, and audible appliance operation and other relayed functions.

1.4.5 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door where terminal strips are securely mounted inside the cabinet.

1.4.6 Control Module and Relay Module

Terms utilized to describe emergency control function interface devices as defined by NFPA 72.

1.4.7 Designated Fire Protection Engineer (DFPE)

The DoD fire protection engineer that oversees that Area of Responsibility for that project. This is sometimes referred to as the "cognizant" fire protection engineer. Interpret reference to "authority having jurisdiction" and/or AHJ in referenced standards to mean the Designated Fire Protection Engineer (DFPE). The DFPE may be responsible for review of the contractor submittals having a "G" designation, and for witnessing final inspection and testing.

1.4.8 Qualified Fire Protection Engineer (QFPE)

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

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.

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

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

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G, R0

Fire alarm system designer; G, R0

Supervisor; G, R0

Technician; G, R0

Installer; G, R0

Test Technician; G, R0

Fire Alarm System Site-Specific Software Acknowledgement; G, R0

SD-02 Shop Drawings

Nameplates; G, R0
Instructions; G, R0
Wiring Diagrams; G, R0
System Layout; G, R0
Notification Appliances; G, R0
Initiating devices; G, R0
Amplifiers; G, R0
Battery Power; G, R0
Voltage Drop Calculations; G, R0

SD-03 Product Data

Fire Alarm and Mass Notification Control Unit (FMCU); G, R0
Local Operating Console (LOC); G, R0
Amplifiers; G, R0
Tone Generators; G, R0
Digitalized voice generators; G, R0
LCD Annunciator; G, R0
Manual Stations; G, R0
Smoke Detectors; G, R0
Duct Smoke Detectors; G, R0
Carbon monoxide detector; G, R0
Addressable Interface Devices; G, R0
Addressable Control Modules; G, R0
Notification Appliances; G, R0
Textual Display Signs; G, R0
Batteries; G, R0
Battery Chargers; G, R0
Supplemental Notification Appliance Circuit Panels; G, R0
Auxiliary Power Supply Panels; G, R0
Surge Protective Devices; G, R0

Alarm Wiring; G, R0

Back Boxes and Conduit; G, R0

Ceiling Bridges for Ceiling-Mounted Appliances; G, R0

Terminal Cabinets; G, R0

Automatic Fire Alarm Transmitters (including housing); G, R0

Mass Notification Transceiver; G, R0

Environmental Enclosures or Guards; G, R0

Document Storage Cabinet; G, R0

SD-05 Design Data

SD-06 Test Reports

Test Procedures; G, R0

SD-07 Certificates

Verification of Compliant Installation; G, R0

Request for Government Final Test; G, R0

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G, R0

Instruction of Government Employees; G, R0

SD-11 Closeout Submittals

As-Built Drawings

Spare Parts

1.6 SYSTEM OPERATION

Fire alarm system/mass notification system including textual display sign control panel(s), components requiring power, except for the FMCU(s) power supply, must operate on 24 volts DC unless noted otherwise in this section.

The interior fire alarm and mass notification system must be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864, and UL 2572. Systems meeting UL 2017 only are not acceptable. The system must be activated into the alarm mode by actuation of an alarm initiating device. The system must remain in the alarm mode until the initiating device is reset and the control unit is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, FMCU, or remotely from authorized locations/users.

1.6.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice, Textual)

- a. Connect alarm initiating devices to initiating device circuits (IDC) Class "A", or to signaling line circuits (SLC) Class "A" and installed in accordance with NFPA 72.
- b. Connect notification appliances to notification appliance circuits (NAC) Class "A".

1.6.2 Functions and Operating Features

The system must provide the following functions and operating features:

- a. Power, annunciation, supervision, and control for the system. Addressable systems must be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.
- b. Visual alarm notification appliances must be synchronized as required by NFPA 72.
- c. Electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control unit.
- d. An audible and visual trouble signal to activate upon a single break or open condition, or ground fault. The trouble signal must also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory control unit modules. After the system returns to normal operating conditions, the trouble signal must again sound until the trouble is acknowledged. A smoke detector in the process of being verified for the actual presence of smoke must not initiate a trouble condition.
- e. A trouble signal silence feature that must silence the audible trouble signal, without affecting the visual indicator.
- f. Program capability via switches in a locked portion of the FMCU to bypass the automatic notification appliance circuits, air handler shutdown features. Operation of this programmed action must indicate on the FMCU display as a supervisory or trouble condition.
- g. Alarm functions must override trouble or supervisory functions. Supervisory functions must override trouble functions.
- h. The system must be capable of being programmed from the control unit keyboard. Programmed information must be stored in non-volatile memory.
- i. The system must be capable of operating, supervising, and/or monitoring non-addressable alarm and supervisory devices.
- j. There must be no limit, other than maximum system capacity, as to the number of addressable devices that may be in alarm simultaneously.
- k. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system, such as HVAC the addressable fire alarm relay must be located in the

vicinity of the emergency control device.

l. An alarm signal must automatically initiate the following functions:

- (1) Transmission of an alarm signal to a remote supervising station.
- (2) Visual indication of the device operated on the FMCU and on the graphic remote annunciator.
- (4) Actuation of alarm notification appliances.
- (5) Recording of the event electronically in the history log of the FMCU.

(13) Refer to Drawings for additional requirements.

m. A supervisory signal must automatically initiate the following functions:

- (1) Visual indication of the device operated on the FMCU and on the graphic remote annunciator. Indication on the graphic annunciator must be by floor, zone or circuit, and type of device.
- (3) Transmission of a supervisory signal to a remote supervising station.
- (4) Operation of a duct smoke detector must shut down the appropriate air handler in accordance with NFPA 90A in addition to other requirements of this paragraph and as allowed by NFPA 72.
- (5) Recording of the event electronically in the history log of the FMCU.

(6) Refer to Drawings for additional requirements.

n. A trouble condition must automatically initiate the following functions:

- (1) Visual indication of the device operated on the FMCU and on the graphic remote annunciator.
- (3) Transmission of a trouble signal to a remote supervising station.
- (4) Recording of the event electronically in the history log of the FMCU.

(5) Refer to Drawings for additional requirements.

o. Activation of a carbon monoxide alarm initiating device must automatically initiate the following functions:

- (1) Visual indication of the device operated on the FMCU, graphic remote annunciator. Indication on the graphic annunciator must be by floor and room number, device address, and device type.
- (2) Transmission of a carbon monoxide alarm signal to the a remote supervising station.
- (3) Activation of all strobes and the audible carbon monoxide message

throughout the building.

(4) Recording of the event electronically in the history log of the FMCU.

(5) Refer to Drawings for additional requirements.

p. System control equipment must be programmed to provide a 60-minute to 180-minute delay in transmission of trouble signals resulting from primary power failure.

q. Activation of a LOC pushbutton must activate the audible and visual alarms in the facility. The audible message must be the one associated with the pushbutton activated.

1.7 TECHNICAL DATA AND SITE-SPECIFIC SOFTWARE

Technical data and site-specific software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be required in other specifications, must be delivered, strictly in accordance with the CONTRACT CLAUSES. The fire alarm system manufacturer must submit written confirmation of this contract provision as "[Fire Alarm System Site-Specific Software Acknowledgement](#)". Identify data delivered by reference to the specification paragraph against which it is furnished. Data to be submitted must include complete system, equipment, and software descriptions. Descriptions must show how the equipment will operate as a system to meet the performance requirements of this contract. The site-specific software data package must also include the following:

- a. Items identified in [NFPA 72](#), titled "Site-Specific Software".
- b. Identification of programmable portions of the system equipment and capabilities.
- c. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.
- d. Provision of operational software data on all modes of programmable portions for fire alarm and mass notification.
- e. Description of Fire Alarm and Mass Notification Control Unit equipment operation.
- f. Description of auxiliary and remote equipment operations.
- g. Library of application software.
- h. Operation and maintenance manuals.

1.8 QUALITY ASSURANCE

1.8.1 Submittal Documents

1.8.1.1 Preconstruction Submittals

Within 36 days of contract award but not less than 14 days prior to commencing any work on site, the Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications of the fire alarm

subcontractor and QFPE must be returned disapproved without review. All resultant delays must be the sole responsibility of the Contractor.

1.8.1.2 Shop Drawings

Shop drawings must not be smaller than ANSI D. Drawings must comply with the requirements of **NFPA 72** and **NFPA 170**. Minimum scale for floor plans must be 1/8"=1'.

1.8.1.3 Nameplates

Nameplate illustrations and data to obtain approval by the Contracting Officer before installation.

1.8.1.4 Wiring Diagrams

Six copies of point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote FMCU, initiating circuits, switches, relays and terminals, including pathway diagrams between the control unit and shared communications equipment within the protected premises. Point-to-point wiring diagrams must be job specific and must not indicate connections or circuits not being utilized. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Include a color-code schedule for the wiring.

1.8.1.5 System Layout

Six copies of plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, conduit sizes, wire counts, conduit fill calculations, wire color-coding, circuit identification in each conduit, and circuit layouts for all floors. Indicate candela rating of each visual notification appliance. Indicate the wattage of each speaker. Clearly identify the locations of isolation modules. Indicate the addresses of all devices, modules, relays, and similar. Show/identify all acoustically similar spaces. Indicate if the environment for the FMCU is within its environmental listing (e.g. temperature/humidity).

Provide a complete description of the system operation in matrix format similar to the "Typical Input/Output Matrix" included in the Annex of **NFPA 72**.

1.8.1.6 Notification Appliances

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances. Annotate data for each circuit on the drawings.

1.8.1.7 Initiating Devices

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings.

1.8.1.8 Amplifiers

Calculations and supporting data to indicate that amplifiers have sufficient capacity to simultaneously drive all notification speakers at tapped settings plus 25 percent spare capacity. Annotate data for each circuit on the drawings.

1.8.1.9 Battery Power

Calculations and supporting data as required in paragraph Battery Power Calculations for alarm, alert, and supervisory power requirements. Calculations including ampere-hour requirements for each system component and each control unit component, and the battery recharging period, must be included on the drawings.

1.8.1.10 Voltage Drop Calculations

Voltage drop calculations for each notification circuit indicating that sufficient voltage is available for proper operation of the system and all components, at a minimum rated voltage of the system operating on batteries. Include the calculations on the system layout drawings.

1.8.1.11 Product Data

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

Provide an equipment list identifying the type, quantity, make, and model number of each piece of equipment to be provided under this submittal. The equipment list must include the type, quantity, make and model of spare equipment. Types and quantities of equipment submitted must coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

1.8.1.12 Operation and Maintenance (O&M) Instructions

Six copies of the Operation and Maintenance Instructions. The O&M Instructions must be prepared in a single volume or in multiple volumes, with each volume indexed, and may be submitted as a Technical Data Package. Manuals must be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions must include the following:

- a. "Manufacturer Data Package five" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.
- b. Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual must include the manufacturer's name, model number, service manual, parts list, and preliminary equipment list complete with description of equipment and their basic operating features.
- c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals must include conduit layout, equipment layout and simplified wiring, and

control diagrams of the system as installed.

- d. Complete procedures for system revision and expansion, detailing both equipment and software requirements.
- e. Software submitted for this project on CD/DVD media utilized.
- f. Printouts of configuration settings for all devices.
- g. Routine maintenance checklist. The routine maintenance checklist must be arranged in a columnar format. The first column must list all installed devices, the second column must state the maintenance activity or state no maintenance required, the third column must state the frequency of the maintenance activity, and the fourth column provided for additional comments or reference. All data (devices, testing frequencies, and similar) must comply with [UFC 3-601-02](#).
- h. A final Equipment List must be submitted with the Operating and Maintenance (O&M) manual.

1.8.1.13 [As-Built Drawings](#)

The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of the as-built (marked-up) drawings must be provided at the time of, or prior to the final Government test.

1.8.2 [Qualifications](#)

1.8.2.1 [Fire Alarm System Designer](#)

The fire alarm system designer must be certified as a Level III (minimum) Technician by National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology or meet the qualifications for a QFPE.

1.8.2.2 [Supervisor](#)

A NICET Level III or IV fire alarm technician must supervise the installation of the fire alarm/mass notification system. The fire alarm technicians supervising the installation of equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.3 [Technician](#)

Fire alarm technicians with a minimum of four years of experience must be utilized to install and terminate fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians installing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.4 [Installer](#)

NICET Level II technician to assist in the installation of fire alarm/mass notification devices, cabinets and control units. A licensed electrician must be allowed to install wire, cable, conduit and backboxes

for the fire alarm system/mass notification system. The fire alarm installer must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.5 Test Technician

Fire alarm technicians with a minimum of eight years of experience and NICET Level III or IV utilized in testing and certification of the installation of the fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians testing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment installed as part of this project.

1.8.2.6 Manufacturer

Components must be of current design and must be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as specified herein.

1.8.3 Regulatory Requirements

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

1.9 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.10 MAINTENANCE

1.10.1 Spare Parts

Furnish the following spare parts in the manufacturers original unopened containers:

- a. Five complete sets of system keys.
- b. Two of each type of fuse required by the system.
- c. One manual stations.
- d. Two of each type of detector installed.
- e. Two of each type of detector base and head installed.
- i. Two of each type of audible and visual alarm device installed.
- j. One textual visual notification appliance.

- k. Two of each type of addressable monitor module installed.
- l. Two of each type of addressable control module installed.
- m. Two low voltage, , and one 120 VAC surge protective device.

1.10.2 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment must be furnished to the Contracting Officer, prior to the instruction of Government employees.

PART 2 PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment must be listed for use under the applicable reference standards. Interfacing of [UL 864](#) or similar approved industry listing with Mass Notification equipment listed to [UL 2572](#) must be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory and listed for fire protection service when so required by [NFPA 72](#) or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment must be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

2.2.2 Nameplates

Major components of equipment must have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

a. FMCU

Nameplates must be etched metal or plastic, permanently attached by screws to control units or adjacent walls.

2.2.3 Keys

Keys and locks for equipment, control units and devices must be identical. Master all keys and locks to a single key as required by the Installation Fire Department.

2.2.4 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a

Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the FMCU. The card must show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions must also include procedures for operating live voice microphones. The instructions and their mounting location must be approved by the Contracting Officer before being posted.

2.3 FIRE ALARM AND MASS NOTIFICATION CONTROL UNIT

Provide a complete **fire alarm and mass notification control unit (FMCU)** fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care, maintenance, and use of the system must be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control unit, the unit cabinets must match exactly. The system must be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling such as waterflow switches, valve supervisory switches, fire pump monitoring, independent smoke detection systems, relays for output function actuation.

- a. Each control unit must provide power, supervision, control, and logic for the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit must be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each control unit with supervisory functions for power failure, internal component placement, and operation.
- b. Visual indication of alarm, supervisory, or trouble initiation on the FMCU must be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit must have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.
- c. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight prerecorded messages. Provide the ability to automatically repeat prerecorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, initiate/synchronize strobes and initiate textual visual notification appliances. Provide a complete set of self-diagnostics for controller and appliance network. Provide local diagnostic information display and local diagnostic information and system event log file.

2.3.1 Cabinet

Install control unit components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface **or** semi-recessed mounting provisions. The enclosure must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must say "Fire Alarm and Mass Notification control unit" and must not be less than **1-inch** high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and

switches.

2.3.2 Silencing Switches

2.3.2.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCU that must silence the audible and visual notification appliances. Subsequent activation of initiating devices must cause the notification appliances to re-activate.

2.3.2.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch(es) that must silence the audible trouble and supervisory signal(s), but not extinguish the visual indicator. This switch must be overridden upon activation of a subsequent supervisory or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated if the supervisory or trouble condition still exists.

2.3.3 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Initiating devices must be manually reset by switch from the FMCU after the initiating device or devices have been restored to normal.

2.3.4 Audible Notification System

The Audible Notification System must comply with the requirements of **NFPA 72** for Emergency Voice/Alarm Communications System requirements, except as specified herein. The system must be a one-way, multi-channel voice notification system incorporating user selectability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of recorded messages. Audible appliances must produce a three-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced. **For carbon monoxide detector activation, audible appliances must produce a four-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced.** Automatic messages must be broadcast through speakers throughout the building/facility but not in stairs. A live voice message must override the automatic audible output through use of a microphone input at the control unit or the LOC.

- a. When using the microphone, live messages must be broadcast throughout a selected floor or floors, or all call. The system must be capable of operating all speakers at the same time. Activation of the public address microphone must not initiate activation of visual notification appliances or LED text displays.
- b. The microprocessor must actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative must automatically cause the three-pulse temporal pattern to take over all functions assigned to the failed unit in the event an alarm is activated.

2.3.4.1 Outputs and Operational Modules

All outputs and operational modules must be fully supervised with on-board diagnostics and trouble reporting circuits. Provide form "C" contacts for system alarm and trouble conditions. Provide circuits for operation of auxiliary appliance during trouble conditions. During a Mass Notification event, the control unit must not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.3.4.2 Mass Notification

- a. The system must have the capability of utilizing an LOC with redundant controls of the FMCU. Notification Appliance Circuits (NAC) must be provided for the activation of strobe appliances. Audio output must be selectable for line level. A hand-held microphone must be provided and, upon activation, must take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC circuit activation.
- b. The Mass Notification functions must override the manual or automatic fire alarm notification,. Other fire alarm functions including transmission of a signal(s) to the fire department must remain operational. All prerecorded messages shall automatically shut off at 10 minutes. At the end of 10 minutes the MNS devices shall shut off and the FA notification devices shall reactivate When a mass notification announcement is disengaged and a fire alarm condition still exists, the audible and visual notification appliances must resume activation for alarm conditions. The fire alarm message must be of lower priority than all other messages (except any "test" messages) and must not override any other messages.
- c. Messages must be recorded professionally utilizing standard industry methods, in a professional female voice. Message and tone volumes must both be at the same decibel level. Verify messages and message priorities with the Installation Fire Department. Message priorities shall be as follows: MNS main panel microphone, LOC's, MNS main panel prerecorded messages circuits 1-5 (1 given the highest priority), fire alarm, carbon monoxide, test, and all clear. Messages recorded from the system microphone must not be accepted. Temporal alert tone (as required by NFPA 72) or other alert tones must precede messages and be similar to the following unless Installation or Facility specific messages are required:
 - (1) Chemical - (Alert Sound - Siren - 600-1250 Hz up and down sweep in 4 seconds; 1.5 second delay <TWO ROUNDS>)
"May I have your attention please. There has been a chemical incident. Stay inside buildings and close windows and doors unless advised by authorities to evacuate. Please shutdown your HVAC system." <PAUSE 2 SECONDS> REPEAT MESSAGE.
(Chemical MNS activation will shut down facility HVAC system.)
 - (2) Bomb - (Alert Sound - Siren - 600-1250 Hz up and down sweep in 4 seconds; 1.5 second delay <TWO ROUNDS>)
"May I have your attention please. There has been a bomb threat in your area. Please evacuate in an orderly fashion to your rally point." <PAUSE 2 SECONDS> REPEAT MESSAGE.
 - (3) Intruder - (Alert Sound - Siren - 600-1250 Hz up and down sweep in 4 seconds; 1.5 second delay <TWO ROUNDS>)

"May I have your attention please. There is an intruder in your area. Please lock all windows and doors immediately. Only admit authorized personnel." <PAUSE 2 SECONDS> REPEAT MESSAGE.

- (4) Severe Weather - (NOAA Standard Alert Tone - 1050 Hz (8 seconds))
"May I have your attention please. A severe weather warning has been issued for area. Seek shelter immediately." <PAUSE 2 SECONDS> REPEAT MESSAGE.
- (5) Secondary Egress - (Alert Sound - Hi-Lo - 780 to 600 Hz alternately, 0.5s each <TWO ROUNDS>)
"May I have your attention please. An emergency has been reported in the facility. Please exit the facility through the secondary exits. Please do not use the main entrance." <PAUSE 2 SECONDS> REPEAT MESSAGE.
- (6) Fire - (TEMPORAL THREE ALERT TONE) <TWO ROUNDS>
"May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit or exit stairway." <PAUSE 2 SECONDS> REPEAT MESSAGE.
- (7) Carbon Monoxide - (TEMPORAL FOUR ALERT TONE) <TWO ROUNDS>
"May I have your attention please. May I have your attention please. Carbon monoxide has been detected in the building. Please walk to the nearest exit and leave the building." <PAUSE 2 SECONDS> REPEAT MESSAGE.
- (8) Test - (Alert Sound - Siren - 600-1250 Hz up and down sweep in 4 seconds; 1.5 second delay <TWO ROUNDS>)
"May I have your attention please. This is a test of the building mass notification system. Please continue your normal duties. This is only a test." (Provide a 2 second pause.) REPEAT MESSAGE.
- (9) All Clear - (Ding-Dong - Percussive pairs of 700 and 570 Hz tones each damped to zero) <ONE ROUND>
"May I have your attention please. An all clear has been issued, resume normal activities." (Provide a 2 second pause.) REPEAT MESSAGE.

- d. Auxiliary Input Module must be designed to be an outboard expansion module to either expand the number of optional LOC's, or allow a telephone interface.

2.3.4.3 Installation-Wide Control

If an installation-wide control system for mass notification exists on the Base, the autonomous control unit must communicate with the central control unit of the Installation-wide system. The autonomous control unit must receive commands/messages from the central control unit and provide status information.

2.3.5 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices must not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.3.6 Field Programmability

Provide control units and control units that are fully field programmable for both input and output of control, initiation, notification, supervisory, and trouble functions. The system program configuration must be menu driven. System changes must be password protected. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system must be provided as part of this contract.

2.3.7 Input/Output Modifications

The FMCU must contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features must consist of a control unit mounted keypad. Any bypass or modification to the system must indicate a trouble condition on the FMCU.

2.3.8 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory or trouble condition on the system still exists.

2.3.9 Walk Test

The FMCU must have a walk test feature. When using this feature, operation of initiating devices must result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated in the history log, but no other outputs occur.

2.3.10 History Logging

The control unit must have the ability to store a minimum of 400 events in a log. These events must be stored in a battery-protected memory and must remain in the memory until the memory is downloaded or cleared manually. Resetting of the control unit must not clear the memory.

2.3.11 Manual Access

An operator at the control unit, having a proper access level, must have the capability to manually access the following information for each initiating device.

- a. Primary status.
- b. Device type.
- c. Present average value.
- d. Present sensitivity selected.
- e. Detector range (normal, dirty).

2.4 LOCAL OPERATING CONSOLES (LOC)

2.4.1 General

The LOC must consist of a remote microphone station incorporating a push-to-talk (PTT) hand-held microphone and system status indicators. The

LOC must have the capability of being utilized to activate prerecorded messages. The unit must incorporate microphone override of any tone generation or recorded messages. The unit must be fully supervised from the FMCU. The housing for the LOC must not be lockable.

2.4.2 Multiple LOCs

When an installation has more than one LOC, the LOCs must be programmed to allow only one LOC to be available for paging or messaging at a time. Once one LOC becomes active, all other LOC's will have an indication that the system is busy (Amber Busy Light) and cannot be used at that time. This is to avoid two messages being given at the same time. It must be possible to override or lockout the LOC's from the FMCU.

2.5 AMPLIFIERS, PREAMPLIFIERS, TONE GENERATORS

Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 must be housed in a remote FMCU, terminal cabinet, or in the FMCU. Individual amplifiers must be 100 watts maximum.

2.5.1 Operation

The system must automatically operate and control all building speakers.

2.5.2 Construction

Amplifiers must utilize computer grade solid state components and must be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.

2.5.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and control unit mounted microphone . Microphone inputs must be of the low impedance, balanced line type. Both microphone and tone generator input must be operational on any amplifier.

2.5.4 Tone Generator

The tone generator must produce a three-pulse temporal pattern and must be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator must be single channel with an automatic backup generator per channel such that failure of the primary tone generator causes the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay. The tone generator must be provided with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces.

2.5.5 Protection Circuits

Each amplifier must be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component must cause illumination of a visual "amplifier trouble" indicator on the control unit, appropriate logging of the condition in the

history log, and other actions for trouble conditions as specified.

2.6 REMOTE ANNUNCIATOR

2.6.1 LCD Annunciator

Provide a semi-recessed mounted annunciator that includes an LCD display. The display must indicate the device in trouble/alarm or any supervisory device. Display the device name, address. The remote annunciator must duplicate functions of the FMCU for message display, fire alarm, supervisory alarm, and trouble conditions, visual and audible notification, and system reset functions. Remote annunciator must require the use of a key for accessing the reset, control and other functions.

A building floor plan must be provided and mounted (behind Plexiglass or similar protective material) at the annunciator location. The floor plan must indicate all rooms by name and number including the locations of stairs. The floor plan must show all devices and their programmed address to facilitate identification of their physical location from the LCD display information.

2.7 MANUAL STATIONS

Provide metal or plastic, surface mounted, double-action, addressable manual stations, that are not subject to operation by jarring or vibration. Stations must be equipped with screw terminals for each conductor. Stations that require the replacement of any portion of the device after activation are not permitted. Stations must be finished in red with molded raised lettering operating instructions of contrasting color. The use of a key must be required to reset the station.

2.8 SMOKE DETECTORS

2.8.1 Spot Type Detectors

Provide addressable photoelectric smoke detectors as follows:

- a. Provide analog/addressable photoelectric smoke detectors utilizing the photoelectric light scattering principle for operation in accordance with [UL 268](#). Smoke detectors must be listed for use with the FMCU.
- b. Provide self-restoring type detectors that do not require any readjustment after actuation at the FMCU to restore them to normal operation. The detector must have a visual indicator to show actuation.
- c. Vibration must have no effect on the detector's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen must not inhibit the movement of smoke particles into the chamber.
- d. Provide twist lock bases with sounder that produces a minimum of 90 dBA at [10 feet](#) with screw terminals for each conductor. The detectors must maintain contact with their bases without the use of springs.
- e. The detector address must identify the particular unit, its location within the system, and its sensitivity setting. Detectors must be of the low voltage type rated for use on a 24 VDC system.

- f. Dwelling unit smoke detectors must contain sounder bases. Sounder bases must be UL listed for 520 Hz (low frequency). Smoke detectors/sounder bases in dwelling units must be interconnected in such a manner that the activation of one alarm will activate all the alarms in that dwelling unit. See Fire Alarm Matrix for signal transmission requirements.

2.8.2 Duct Smoke Detectors

Duct-mounted addressable photoelectric smoke detectors must consist of a smoke detector, as specified in paragraph Spot Type Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry must be mounted in a metallic or plastic enclosure exterior to the duct. It is not permitted to cut the duct insulation to install the duct detector directly on the duct. Detectors must be listed for operation over the complete range of air velocities, temperature and humidity expected at the detector when the air-handling system is operating. Detectors must be powered from the FMCU.

- a. Sampling tubes must run the full width of the duct. The duct detector package must conform to the requirements of NFPA 90A, UL 268A, and must be listed for use in air-handling systems. The control functions, operation, reset, and bypass must be controlled from the FMCU.
- b. Lights to indicate the operation and alarm condition must be visible and accessible with the unit installed and the cover in place. Remote indicators must be provided where required by NFPA 72. Remote indicators as well as the affected fan units must be properly identified in etched plastic placards.
- c. Detectors must provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 00 to INSTRUMENTATION AND CONTROL FOR HVAC. Auxiliary contacts provide for this function must be located within 3 feet of the controlled circuit or appliance. The auxiliary contacts must be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.9 CARBON MONOXIDE DETECTOR

Analog/addressable carbon monoxide (CO) detectors must be listed to UL 2075 and set to respond to the sensitivity limits of UL 2034. Carbon monoxide detectors must be listed for use with fire alarm control units. Detectors must be self-restoring. For FMCU with no listed compatible addressable CO detectors, provide listed 4-wire detectors. Detector must be provided with an LED status indicator.

- a. Where 4-wire CO detectors are necessary, each 4-wire CO detector must be individually monitored via addressable interface modules for alarm and off normal/trouble conditions (including loss of power to the individual detector). Power circuits for 4-wire CO detectors must be dedicated to powering the CO detectors only. Battery powered and 120 VAC powered detectors are prohibited.
- b. Wiring connections must be made by means of screw terminals and detectors must be equipped with trouble relays. Detectors must be able to mount a single-gang electrical box.

- c. A trouble condition at an individual CO detector must not affect any other CO detectors. CO detectors must be powered by the FMCU.
- d. Detectors must be provided with a means to test CO gas entry into the CO sensing cell.

2.10 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored must be configured as a Class "A" initiating device circuits. The module must be listed as compatible with the control unit. The module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. Monitor module must contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Pull stations with a monitor module in a common backbox are not required to have an LED. Modules must be listed for the environmental conditions in which they will be installed.

2.11 ADDRESSABLE CONTROL MODULES

The control module must be capable of operating as a relay (dry contact form C) for interfacing the control unit with other systems, and to control door holders. The module must be listed as compatible with the control unit. The indicating device or the external load being controlled must be configured as Class A notification appliance circuits. The system must be capable of supervising, audible, visual and dry contact circuits. The control module must have both an input and output address. The supervision must detect a short on the supervised circuit and must prevent power from being applied to the circuit. The control module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. The control module must contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules must be listed for the environmental conditions in which they will be installed.

2.12 NOTIFICATION APPLIANCES

2.12.1 Audible Notification Appliances

Audible appliances must conform to the applicable requirements of [UL 464](#). Audible appliances in sleeping rooms must be UL listed for 520 Hz (low frequency). Appliances must be connected into notification appliance circuits. Surface mounted audible appliances must be painted red. Recessed audible appliances must be installed with a grill that is painted red. Audible notification appliances in the drying tower shall be rated for 140 degrees F.

2.12.1.1 Speakers

- a. Speakers must conform to the applicable requirements of [UL 1480](#). Speakers must have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Interior speaker tap settings must include taps of 1/4, 1/2, 1, and 2 watt, at a minimum. Exterior speakers must also be multi-tapped with no more than 15 watt maximum setting. Speakers must incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 400 Hz to 4,000 Hz, and must have a sealed back construction. Speakers must be capable of

installation on standard 4-inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single unit. All inputs must be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCU.

- b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gage or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes must be ground and finished to provide a smooth and neat appearance for each plate. Each plate must be primed and painted.
- c. Speakers must utilize screw terminals for termination of all field wiring.

2.12.2 Visual Notification Appliances

Visual notification appliances must conform to the applicable requirements of UL 1638, UL 1971 and conform to the Architectural Barriers Act (ABA). Visual Notification Appliances must have clear high intensity optic lens, xenon flash tubes, or light emitting diode (LED) and be marked "Alert" in letters of contrasting color. The light pattern must be dispersed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate must be 1 flash per second and a candela rating shown on plans based on the UL 1971 test. Strobe must be surface mounted. Visible notification appliances in the drying tower shall be rated for 140 degrees F.

2.12.3 Textual Display Signs

Textual display signs must be LED and must not exceed 16 inches long by 6 inches high by 3 inches deep with a height necessary to meet the requirements of NFPA 72. The text display must spell out the word "EVACUATE" or "ANNOUNCEMENT" as appropriate. The design of text display must be such that it cannot be read when not illuminated.

2.13 ELECTRIC POWER

2.13.1 Primary Power

Power must be 120 VAC 60 Hz service for the FMCU from the AC service to the building in accordance with NFPA 72.

2.14 SECONDARY POWER SUPPLY

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

2.14.1 Batteries

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

2.14.1.1 Capacity

Battery size must be the greater of the following two capacities. This capacity applies to every control unit associated with this system, including supplemental notification appliance circuit panels, auxiliary power supply panels, fire alarm transmitters, and Base-wide mass notification transceivers. When determining the required capacity under alarm condition, visual notification appliances must include both textual and non-textual type appliances.

- a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 48 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.
- b. Sufficient capacity to operate the mass notification for 60 minutes after loss of AC power.

2.14.1.2 Battery Power Calculations

- a. Verify that battery capacity exceeds supervisory and alarm power requirements for the criteria noted in the paragraph "Capacity" above.
 - (1) Substantiate the battery calculations for alarm and supervisory power requirements. Include ampere-hour requirements for each system component and each control unit component, and compliance with [UL 864](#).
 - (2) Provide complete battery calculations for both the alarm and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.
 - (3) Provide voltage drop calculations to indicate that sufficient voltage is available for proper operation of the system and all components. Calculations must be performed using the minimum rated voltage of each component.
- b. For battery calculations assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Using 20.4 VDC as starting voltage, perform a voltage drop calculation for circuits containing device and/or appliances remote from the power sources.

2.14.2 Battery Chargers

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

2.15 SURGE PROTECTIVE DEVICES

Surge protective devices must be provided to suppress all voltage transients which might damage fire alarm control unit components. Systems having circuits located outdoors, communications equipment must be protected against surges induced on any signaling line circuit. Cables and conductors, that serve as communications links, must have surge protection circuits installed at each end. The surge protective device must wire in series to the power supply of the protected equipment with screw terminations. Line voltage surge arrestor must be installed directly adjacent to the power panel where the FMCU breaker is located.

- a. Surge protective devices for nominal 120 VAC must be UL 1449 listed with a maximum 500 volt suppression level and have a maximum response time of 5 nanoseconds. The surge protective device must also meet IEEE 62.41.1 and IEEE 62.41.2 category B tests for surge capacity. The surge protective device must feature multi-stage construction and be provided with a long-life indicator lamp (either light emitting diode or neon) which extinguishes upon failure of protected components. Any unit fusing must be externally accessible.
- b. Surge protective devices for nominal 24 VAC, fire alarm telephone dialer, or ethernet connection must be UL 497B listed, meet IEEE 62.41.1 and have a maximum response time of 1-nanosecond. The surge protective device must feature multi-stage construction and be self-resetting. The surge protective device must be a base and plug style. The base assembly must have screw terminals for fire alarm wiring. The base assembly must accept "plug-in" surge protective module.
- c. All surge protective devices (SPD) must be the standard product of a single manufacturer and be equal or better than the following:
 - (1) For 120 VAC nominal line voltage: UL 1449 and UL 1283 listed, series connected 120 VAC, 20A rated, surge protective device in a NEMA 4x enclosure. Minimum 50,000 amp surge current rating with EMI/RFI filtering and a dry contact circuit for remote monitoring of surge protection status.
 - (2) For 24-volt nominal line voltage: UL 497B listed, series connected low voltage, 24-volt, 5A rated, loop circuit protector, base and replaceable module.
 - (3) For alarm telephone dialers: UL 497A listed, series connected, 130-volt, 150 mA rated with self-resetting fuse, dialer circuit protector with modular plug and play.
 - (4) For IP-DACTS: UL 497B listed, series connected, 6.4-volt, 1.5A rated with 20 kA/pair surge current, data network protector with modular plug and play.

2.16 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein. All fire alarm and mass notification wiring shall be installed in factory-painted, red conduit. All junction boxes shall be painted red.

2.16.1 Alarm Wiring

IDC and SLC wiring must be solid copper cable in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring must be No. 14 AWG size conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, must be copper No. 14 AWG size conductors at a minimum. Speaker circuits must be copper No. 16 AWG size twisted and shielded conductors at a minimum. Wiring for textual notification appliance circuits must be in accordance with manufacturer's requirements but must be supervised by the FMCU. Wire size must be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC must not operate at less than the listed voltages for the detectors and/or appliances. Power wiring, operating at 120 VAC minimum, must be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Nonpower-limited cables must comply with NFPA 70.

2.17 INTERFACE TO THE BASE-WIDE MASS NOTIFICATION NETWORK

2.17.1 Radio

The mass notification transceiver must be bi-direction and meet all the requirements of paragraph, RADIO TRANSMITTER AND INTERFACE PANELS as specified in this specification section. The transceiver utilized in the mass notification system must be capable of the following:

- a. Communication with the central control/monitoring system to provide supervision of communication link and status changes are reported by automatic and manual poll/reply/acknowledge routines.
- b. All monitored points/status changes are transmitted immediately and at programmed intervals until acknowledged by the central control/monitoring system.
- c. Each transceiver must transmits a unique identity code as part of all messages; the code is set by the user at the transceiver.

2.18 AUTOMATIC FIRE ALARM TRANSMITTERS

2.18.1 Radio Transmitter and Interface Panels

Transmitters must be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter must be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters must be provided in accordance with applicable portions of NFPA 72, Federal Communications Commission (FCC) 47 CFR 90 and Federal Communications Commission (FCC) 47 CFR 15. Transmitter electronics module must be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is shown on drawings and the transmitter must be fully compatible with this equipment. At the contractors option, and if listed, the transmitter may be housed in the same control unit as the FMCU. The transmitter must be narrowband radio, with FCC certification for narrowband operation and meets the requirements of the NTIA (National Telecommunications and Information Administration) Manual of Regulations and Procedures for Federal Frequency Management.

2.18.1.1 Operation

Operate each transmitter from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter must automatically switch to battery operation. Switchover must be accomplished with no interruption of protective service, and must automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply must also be automatic.

2.18.1.2 Battery Power

Transmitter standby battery capacity must provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

2.18.1.3 Transmitter Housing

Use NEMA Type 1 for housing. The housing must contain a lock that is keyed identical to radio alarm transmitter housings on the Installation. Radio alarm transmitter housing must be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.18.1.4 Antenna

Antenna must be omnidirectional, coaxial, halfwave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts must be corrosion resistant and designed to withstand wind velocities of 100 mph. Do not mount antennas to any portion of the building roofing system. Protect the antenna from physical damage.

2.18.2 Signals to Be Transmitted to the Base Receiving Station

Refer to the FA/MNS Matrix on the Drawing for the signals that must be sent to the base receiving station.

2.19 SYSTEM MONITORING

2.19.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, standpipe control valves, sprinkler service entrance valve, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, must be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address.

2.20 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures must be provided to permit fire alarm/mass notification components to be used in areas that exceed the environmental limits of the listing. The enclosure must be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the component is currently listed. Guards required to deter mechanical damage must be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

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

3.2 INSTALLATION

3.2.1 Fire Alarm and Mass Notification Control Unit (FMCU)

Locate the FMCU where indicated on the drawings. Surface mount the enclosure with the top of the cabinet **6 feet** above the finished floor or center the cabinet at **5 feet**, whichever is lower. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the FMCU. Locate the document storage cabinet adjacent to the FMCU unless the Contracting Officer directs otherwise.

3.2.2 Battery Cabinets

When batteries will not fit in the FMCU, locate battery cabinets below or adjacent to the FMCU. Battery cabinets must be installed at an accessible location when standing at floor level. Battery cabinets must not be installed lower than **12 inches** above finished floor, measured to the bottom of the cabinet, nor higher than **36 inches** above the floor, measured to the top of the cabinet. Installing batteries above drop ceilings or in inaccessible locations is prohibited. Battery cabinets must be large enough to accommodate batteries and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions. The cabinet must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must indicate the control unit(s) the batteries power and must not be less than **1-inch** high.

3.2.3 Manual Stations

Locate manual stations as required by **NFPA 72** and as indicated on the drawings. Mount stations so they are located no farther than **5 feet** from the exit door they serve, measured horizontally. Manual stations must be mounted at **48 inches** measured to the operating handle.

3.2.4 Notification Appliances

- a. Locate notification appliance devices as required by **NFPA 72** where indicated and to meet the intelligibility requirements. Where two or more visual notification appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices must use screw terminals for all field wiring. Audible and visual notification appliances mounted in acoustical ceiling tiles must be centered in the tiles plus or minus **2 inches**.

- b. Audible and visual notification appliances mounted on the exterior of the building, within unconditioned spaces, or in the vicinity of showers must be listed weatherproof appliances installed on weatherproof backboxes.
- c. Speakers must not be located in close proximity to the FMCU or LOC so as to cause feedback when the microphone is in use.

3.2.5 Smoke Detectors and Alarms

Locate detectors as required by NFPA 72 and their listing and as indicated on the drawings on a 4-inch mounting box. Install heat detectors not less than 4 inches from a side wall to the near edge. Heat detectors located on the wall must have the top of the detector at least 4 inches below the ceiling, but not more than 12 inches below the ceiling. Smoke detectors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Install smoke detectors no closer than 3 feet from air handling supply diffusers. Detectors installed in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.

3.2.6 Carbon Monoxide Detectors

Locate detectors as required by NFPA 72 and their listings and as indicated on the drawings on a 4-inch mounting box.

3.2.7 LCD REMOTE Annunciator

Locate the LCD annunciator as shown on the drawings. Mount the annunciator, with the top 6 feet above the finished floor or center the annunciator at 5 feet, whichever is lower.

3.2.8 Local Operating Console (LOC)

Locate the LOC(s) as required by NFPA 72 and as indicated. Mount the console so that the top message button and microphone is no higher than 4 feet above the floor and the bottom (lowest) message button and microphone is at least 3 feet above the finished floor.

3.2.9 Ceiling Bridges

Provide ceiling bridges for ceiling-mounted appliances. Ceiling bridges must be as recommended/required by the manufacturer of the ceiling-mounted notification appliance.

3.3 SYSTEM FIELD WIRING

3.3.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box must be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Wiring to conform with NFPA 70.

Indicate the following in the wiring diagrams:

- a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote fire alarm/mass notification control units, initiating circuits, switches, relays and terminals.
- b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.3.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size must be appropriate for the size of the wiring to be connected. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted. Provide an identification label, that displays "FIRE ALARM TERMINAL CABINET" with 2-inch lettering, on the front of the terminal cabinet.

3.3.3 Alarm Wiring

- a. Voltages must not be mixed in any junction box, housing or device, except those containing power supplies and control relays.
- b. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, in or adjacent to the FMCU.
- c. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. T-tapping using screw terminal blocks is allowed for Class "B" signaling line circuits.
- d. Color coding is required for circuits and must be maintained throughout the circuit. Conductors used for the same functions must be similarly color coded. Conform wiring to NFPA 70.
- e. Pull all conductors splice free. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited. Where splices are unavoidable, the location of the junction box or pull box where they occur must be identified on the as-built drawings. The number and location of splices must be subject to approval by the Designated Fire Protection Engineer (DFPE).

3.3.4 Back Boxes and Conduit

In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide all wiring in rigid metal conduit or intermediate metal conduit unless specifically indicated otherwise. Minimum conduit size must be 3/4-inch in diameter. Do not use electrical non-metallic tubing (ENT) or flexible non-metallic tubing and associated fittings.

- a. Galvanized rigid steel (GRS) conduit must be utilized where exposed to

weather, where subject to physical damage, and where exposed on exterior of buildings. Intermediate metal conduit (IMC) may be used in lieu of GRS as allowed by NFPA 70.

- b. Electrical metallic tubing (EMT) is permitted above suspended ceilings or exposed where not subject to physical damage. Do not use EMT underground, encased in concrete, mortar, or grout, in hazardous locations, where exposed to physical damage, outdoors or in fire pump rooms. Use die-cast compression connectors.
- c. For rigid metallic conduit (RMC), only threaded type fitting are permitted for wet or damp locations.
- d. Flexible metal conduit is permitted for initiating device circuits 6 feet in length or less. Flexible metal conduit is prohibited for notification appliance circuits and signaling line circuits. Use liquid tight flexible metal conduit in damp and wet locations.
- e. Schedule 40 (minimum) polyvinyl chloride (PVC) is permitted where conduit is routed underground or underground below floor slabs. Convert non-metallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before turning up through floor slab.
- f. Exterior wall penetrations must be weathertight. Conduit must be sealed to prevent the infiltration of moisture.

3.3.5 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCU, and remote FMCU and the LOC must be provided at each conductor connection. Each conductor or cable must have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCU, and remote FMCU must contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing must be neat, using 12 point lettering minimum size, and mounted within each cabinet, control unit, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.4 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire-rated walls, partitions with fire-rated doors, corridor walls, and vertical service shafts in accordance with Section 07 84 00 FIRESTOPPING.

3.5 PAINTING

- a. Provide factory-painted red electrical conduit.
- b. Paint junction boxes and electrical boxes red. The inside cover of the junction box must be identified as "Fire Alarm".
- c. Painting must comply with Section 09 90 00 PAINTS AND COATINGS.

3.6 FIELD QUALITY CONTROL

3.6.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level III Fire Alarm Technician, and the representative of the installing company, 60 days prior to performing system tests. Detailed test procedures must list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, and surge protective devices. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 72 and NFPA 4.) The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government testing. The test data forms must record the test results and must:

- a. Identify the NFPA Class of all Initiating Device Circuits (IDC), and Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).
- b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how these tests must be performed.
- c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.
- d. Identify all test equipment and personnel required to perform each test (including equipment necessary for smoke detector testing. The use of magnets is not permitted.
- e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.6.2 Pre-Government Testing

3.6.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that devices and circuits are functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" as required by NFPA 72. The contractor and an authorized representative from each supplier of equipment must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 72 including all referenced annex sections and the test reports noted below.

- a. NFPA 72 Record of Completion.

- b. **NFPA 72** Record of Inspection and Testing.
- c. Fire Alarm and Emergency Communication System Inspection and Testing Form.
- d. Audibility test results with marked-up test floor plans.
- e. Intelligibility test results with marked-up floor plans.
- f. Documentation that all tests identified in the paragraph "Minimum System Tests" are complete.

3.6.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the Contracting Officer's Representative (COR). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the installation-wide fire reporting system and the installation-wide mass notification system have been completed and tested to confirm communications are fully functional. Submit request for test at least 15 calendar days prior to the requested test date.

3.6.3 Correction of Deficiencies

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

3.6.4 Government Final Tests

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

- a. The manufacturer's technical representative.
- b. The contractor's Qualified Fire Protection Engineer (QFPE).
- c. Marked-up red line drawings of the system as actually installed.
- d. Loop resistance test results.
- e. Complete program printout including input/output addresses.
- f. Copy of pre-Government Test Certificate, test procedures and completed test data forms.
- g. Audibility test results with marked-up floor plans.
- h. Intelligibility test results with marked-up floor plans.

Government Final Tests will be witnessed by the , Contracting Officer's Representative (COR). At this time, any and all required tests noted in

the paragraph "Minimum System Tests" must be repeated at their discretion.

3.7 MINIMUM SYSTEM TESTS

3.7.1 System Tests

Test the system in accordance with the procedures outlined in [NFPA 72](#).
The required tests are as follows:

- a. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests must be witnessed by the Contracting Officer and test results recorded for use at the final Government test.
- b. Verify the absence of unwanted voltages between circuit conductors and ground. The tests must be accomplished at the pre-Government test with results available at the final system test.
- c. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.
- d. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke detectors must be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors must comply with the requirements of [NFPA 72](#) except disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision must be tested at each device.
- e. Carbon Monoxide Detector Tests: Carbon monoxide detectors must be tested in accordance with [NFPA 72](#) and the manufacturer's recommended calibrated test method.
- f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.
- g. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.
- h. Determine that the system is operable under trouble conditions as specified.
- i. Visually inspect wiring.
- j. Test the battery charger and batteries.
- k. Verify that software control and data files have been entered or programmed into the FMCU. Hard copy records of the software must be provided to the Contracting Officer.
- l. Verify that red-line drawings are accurate.
- m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.
- n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

- o. Disconnect the verification feature for smoke detectors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke detectors must be conducted using real smoke or the use of canned smoke which is permitted.
- p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.
- q. Verify the documentation cabinet is installed and contains all as-built shop drawings, product data sheets, design calculations, site-specific software data package, and all documentation required by paragraph titled "Test Reports".

3.7.2 Audibility Tests

Sound pressure levels from audible notification appliances must be a minimum of 15 dBa over ambient with a maximum of 110 dBa in any occupiable area. The provisions for audible notification (audibility and intelligibility) must be met with doors, fire shutters, movable partitions, and similar devices closed.

3.7.3 Intelligibility Tests

Intelligibility testing of the System must be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, and ASA S3.2. Following are the specific requirements for intelligibility tests:

- a. Intelligibility Requirements: Verify intelligibility by measurement after installation.
- b. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is .8. Rounding of values is permitted.
- c. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the DFPE, and if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 33 feet to find a location with at least the minimum required CIS value within the same area.
- d. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 50 feet to a location with at least the minimum required CIS value within the same area.
- e. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).
- f. The distance the occupant must walk to the location meeting the minimum required CIS value must be measured on the floor or other walking surface as follows:

- (1) Along the centerline of the natural path of travel, starting from

any point subject to occupancy with less than the minimum required CIS value.

- (2) Curving around any corners or obstructions, with a 12 inches clearance there from.
- (3) Terminating directly below the location where the minimum required CIS value has been obtained.

Use commercially available test instrumentation to measure intelligibility as specified by NFPA 72 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.8 SYSTEM ACCEPTANCE

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

- a. Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of AutoCAD, DXF and portable document formats of as-built drawings and schematics.
- b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.
- c. Include a riser diagram and drawings showing the as-built location of devices and equipment.
- d. Provide Operation and Maintenance (O&M) Instructions.

3.9 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.9.1 Instructor

Provide the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the operation, inspection, testing, and maintenance of the system provided. The instructor must train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm system. The instructor must be thoroughly familiar with all parts of this installation. The instructor must be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.9.2 Required Instruction Time

Provide 8 hours of instruction after final acceptance of the system. The instruction must be given during regular working hours on such dates and times selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training must allow for rescheduling for unforeseen maintenance and/or fire department responses.

3.9.3 Technical Training Manual

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training must familiarize designated government personnel with proper operation of the installed system. The maintenance training course must provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

3.10 EXTRA MATERIALS

3.10.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system must be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During the warranty period, the service technician must be on-site within 24 hours after notification. All repairs must be completed within 24 hours of arrival on-site.

During the warranty period, the installing fire alarm contractor is responsible for conducting all required testing and maintenance in accordance with the requirements and recommended practices of NFPA 72 and the system manufacturer. Installing fire alarm contractor is NOT responsible for any damage resulting from abuse, misuse, or neglect of equipment by the end user.

3.10.2 Spare Parts

Spare parts furnished must be directly interchangeable with the corresponding components of the installed system. Spare parts must be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts must be delivered to the Contracting Officer at the time of the Government testing and must be accompanied by an inventory list.

3.10.3 Document Storage Cabinet

Upon completion of the project, but prior to project close-out, place in the document storage cabinet copies of the following record documentation:

- a. As-built shop drawings
- b. Product data sheets
- c. Design calculations
- d. Site-specific software data package
- e. All documentation required by SD-06.

-- End of Section --

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO T 180 (2017) Standard Method of Test for
Moisture-Density Relations of Soils Using
a 4.54-kg (10-lb) Rammer and a 457-mm
(18-in.) Drop

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M (2023) Standard Specification for Concrete
Aggregates

ASTM C117 (2023) Standard Test Method for Materials
Finer than 75-um (No. 200) Sieve in
Mineral Aggregates by Washing

ASTM C136/C136M (2019) Standard Test Method for Sieve
Analysis of Fine and Coarse Aggregates

ASTM C150/C150M (2022) Standard Specification for Portland
Cement

ASTM C260/C260M (2010a; R 2016) Standard Specification for
Air-Entraining Admixtures for Concrete

ASTM C618 (2023; E 2023) Standard Specification for
Coal Fly Ash and Raw or Calcined Natural
Pozzolan for Use in Concrete

ASTM C989/C989M (2024) Standard Specification for Slag
Cement for Use in Concrete and Mortars

ASTM D1140 (2017) Standard Test Methods for
Determining the Amount of Material Finer
than 75-µm (No. 200) Sieve in Soils by
Washing

ASTM D1556/D1556M (2015; E 2016) Standard Test Method for
Density and Unit Weight of Soil in Place
by Sand-Cone Method

ASTM D1557 (2012; E 2015) Standard Test Methods for
Laboratory Compaction Characteristics of
Soil Using Modified Effort (56,000

ft-lbf/ft³) (2700 kN-m/m³)

ASTM D2216 (2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM D2321 (2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D2487 (2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D4318 (2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D4829 (2021) Standard Test Method for Expansion Index of Soils

ASTM D4832 (2016; E 2018) Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

ASTM D6023 (2016) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)

ASTM D6103/D6103M (2017; E 2021) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)

ASTM D6938 (2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D8167/D8167M (2023) Standard Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low-Activity Nuclear Method (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2024) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020 (1983) Methods for Chemical Analysis of Water and Wastes

EPA SW-846.3-3 (1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.2 DEFINITIONS

1.2.1 Structural Fill

Soil material placed to support buildings, walls, pads, and other similar facilities.

1.2.2 Preload Fill

Permanent structural fill placed up to design finish subgrade elevation for purposes of compressing the soil under applied vertical stress prior to construction and placement of final construction load.

1.2.3 Surcharge Fill

Temporary fill placed above the design level for the purposes of accelerating consolidation and reducing structure settlements. Surcharge fill is removed upon completion of desired settlement reduction. The surcharge fill does not need to meet any special requirements other than having a minimum in-place moist unit weight of 115 pounds per cubic foot. Loosely dumped soils are unlikely to achieve this density and therefore compaction control should be anticipated.

1.2.4 Porous Fill

Free-draining material placed for subsurface drainage, as a capillary break, or another specific purpose.

1.2.5 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.6 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.7 Flowable Fill

Flowable fill is a self-compacting low strength material with a flowable consistency that is used as an alternative to compacted granular fill. Terminology used by ACI Committee 229 is Controlled Low Strength Material (CLSM).

1.2.8 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place comprise any materials classified by [ASTM D2487](#) as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML. Maximum particle size to be no greater than [2 inches](#) in any dimension.

1.2.9 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include

man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.10 Cohesionless Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.11 Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines are plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.12 Hard/Unyielding Materials

Hard/Unyielding materials comprised of weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 2 inches in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.13 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or building and appurtenant structures. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.14 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829 or a liquid limit greater than 50 (ASTM D4318).

1.2.15 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.16 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to

the area immediately below a slab.

1.2.17 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in [ASTM D1557](#) abbreviated as a percent of laboratory maximum density. Since [ASTM D1557](#) applies only to soils that have 30 percent or less by weight of their particles retained on the [3/4 inch](#) sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the [3/4 inch](#) sieve as a percentage of the maximum density in accordance with [AASHTO T 180-21](#) paragraph 1.5, Note 1.

1.2.18 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.19 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 SUBSURFACE DATA

Subsurface soil boring logs are shown [in the Subsurface Exploration and Geotechnical Engineering Report dated March 2024](#). These data represent available subsurface information; however, variations may exist between boring locations. A copy of the report is attached.

1.4 CRITERIA FOR BIDDING

Base bids on the following criteria:

- a. Surface elevations are as indicated.
- b. [Material character is indicated by the boring logs \(B-1 through B-8\) and CPTu Soundings \(CPTu-1 and CPTu-2\). Reference Subsurface Exploration and Geotechnical Report dated March 2024. Assume groundwater below El. 9.5 ft. NAVD88](#)
- c. [Hard materials will not be encountered within anticipated construction depths. Very dense soil \(marl\) is present at a depth of approximately 50 feet below existing site grades, approximate El. -37 ft NAVD88.](#)
- d. Pipes or other artificial obstructions, except those indicated, will not be encountered.
- e. For evaluating liquefaction triggering and related phenomena, assume MCEG peak ground acceleration adjusted for site effects, PGAM = 0.231 and Moment Magnitude, MW = 7.3. Assume post-liquefaction settlement of 5-1/2 inches under the tower mat for unimproved ground at design grade.
- f. Main Building: Ground improvement will be necessary for support of the main building foundations and floor slab. Ground improvements shall be designed by the Contractor and include semi-rigid (e.g., stone columns) or rigid inclusions (e.g., grout columns) to limit static

foundation settlements to tolerable levels. Ground improvement design shall be by a Professional Engineer in the State of Georgia, and compliance with the performance requirements shall be the responsibility of the Contractor. Foundation and floor slab loads are detailed in Drawing Sheet S-001. For support of the main building, footings have been preliminarily dimensioned using a maximum net allowable soil bearing pressure of 2,000 psf.

Performance Criteria:

For sustained loads and performance period of 75 years: 1) Maximum total foundation and slab settlements shall be less than 1-inch, and 2) Maximum foundation and slab differential settlements shall be 1/2-inch between column supports and less than 1/2-inch over 30 feet (continuous footings and slab). Mitigation of liquefaction-induced settlement is not required.

- g. Drying Tower: Ground improvement will be necessary for support of the drying tower mat foundation. Ground improvements shall be designed by the Contractor and include semi-rigid (e.g., stone columns) or rigid inclusions (e.g., grout columns) to limit static foundation settlements to tolerable levels.

Ground improvement design shall be by a Professional Engineer in the State of Georgia, and compliance with the performance requirements shall be the responsibility of the Contractor. Mat foundation loads are detailed in Drawing Sheet S-001. For support of the drying tower, a mat foundation has been preliminarily dimensioned using a maximum net allowable soil bearing pressure of 1,500 psf. Contractor shall demonstrate that net allowable bearing capacity is not exceeded.

Performance Criteria:

For sustained loads and performance period of 75 years: 1) Maximum total foundation settlement shall be less than 1-inch, and 2) Maximum differential settlements across the tower mat shall be less than 1/2-inch over 30 feet.

Mitigation of liquefaction-induced settlement is required. Liquefiable soils were encountered to El. -24 ft NAVD888. Mitigation shall include earthquake drains, semi-rigid, or rigid inclusions. Mitigation shall extend to the bottom of the treated layer(s) and extend 25-feet outside of the mat foundation limits. Total post-construction, post-liquefaction settlements shall be 2-inches or less after mitigation. Alternatively, a factor of safety of 1.5 or greater against liquefaction triggering shall be achieved. Densified soils improvement shall be verified by using piezocone penetration testing (ASTM D5778) split-spaced between improvement locations. At least one piezocone penetration test (CPTu) shall be performed between densified columns with the largest spacing. Youd et al. (2001), Moss et al. (2006), and Boulanger and Idriss (2014) can be used to evaluate liquefaction potential of sandy soils.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL

PROCEDURES:

SD-01 Preconstruction Submittals

Excavation and Trenching Plan; G, D0

Ground Improvement Design and Verification Plan; G, D0, ENG-S

Borrow Plan; G, D0 Jacking, Boring, and Tunneling Plan; G

Disposition of Surplus Materials; G, D0

Preconstruction Meeting; G, D0

SD-03 Product Data

Flowable Fill Mix Design; G, D0

Geotextiles

SD-04 Samples

Geotextiles

SD-06 Test Reports

Borrow Site Testing; G, D0

Settlement Monitoring Records; G, D0

Fill and Material Test Reports; G, D0

Geotechnical Evaluation report; G, D0

Pipe Inspection Report; G, D0

1.6 QUALITY CONTROL

1.6.1 Geotechnical Engineer

Provide a Professional Geotechnical Engineer to provide inspection of ground improvement activities, liquefaction mitigation activities, excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for preparing and updating the Ground Improvement and Quality Control Program. Submit a monthly Geotechnical Evaluation report, informing the Contractor and Contracting Officer of the status of the ground improvement and fill placement plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contractor is responsible for arranging meetings with the Geotechnical Engineer and Contracting Officer throughout the contract duration.

1.6.2 Qualified Technician

Provide a Qualified Technician to inspect, monitor, sample, and performing field testing. The technician qualifications need to be one of the following: a current National Institute for Certification in Engineering

Technologies (NICET) Level II minimum certification in Construction Materials Testing Soils; a Geologist-in-Training with minimum one-year experience; an Engineer-in-Training with minimum one-year experience; a Registered Geologist; or a Professional Engineer.

1.6.3 Lab Validation

Perform testing by a Corps validated commercial testing laboratory or Contractor established testing laboratory meeting the requirements of Section 01 45 00.00 10 entitled QUALITY CONTROL and approved by the Contracting Officer. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until testing facilities have been inspected, Corps validated and approved by the Contracting Officer.

1.6.4 Preconstruction Meeting

Conduct a preconstruction meeting at the jobsite at least five business days prior to the start of earthwork operations on the project. The preconstruction meeting is to be arranged by the Contractor and is to follow the written agenda submitted prior to the meeting. The purpose of this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this meeting: Contractor's Project Manager and Project Superintendent, ground improvement contractors representative, earthwork subcontractor's Project Manager and Site Foreman, Contractor's Geotechnical Engineer and Testing Agency, Government Geotechnical Engineer and Civil Engineer, and Government Construction Manager and Engineering Technician.

The minutes of this meeting are to be recorded by the Contractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Fill

Materials classified as GW, GP, GM, GC, GW-GM, GW-GC, GP-GM, GP-GC, GC-GM, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, or CL in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

2.1.2 Embankment Fill

Materials classified as GW, GP, GM, GC, GW-GM, GW-GC, GP-GM, GP-GC, GC-GM, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, or CL in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

2.1.3 Porous Fill

Materials containing less than 5 percent passing the No. 200 sieve. Provide the gradation as appropriate for the intended purpose.

2.1.4 Topsoil

Material suitable for topsoil obtained from approved areas is defined as: Natural, friable soil representative of productive, well-drained soils in

the area, free of subsoil, stumps, rocks larger than [one inch](#) diameter, brush, weeds, toxic substances, and other material detrimental to plant growth.

2.1.5 Capillary Water Barrier

Conform to [ASTM C33/C33M](#) for fine aggregate grading with a maximum of 3 percent by weight passing [ASTM D1140](#), [No. 200](#) sieve, or [1-1/2 inch](#) and no more than 2 percent by weight passing the [No. 4](#) size sieve or coarse aggregate Size 57, 67, or 77.

2.1.6 Utility Bedding Material

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with [ASTM D2321](#). Install bedding for plastic piping to spring line of pipe. Utility bedding material may include the following:

2.1.6.1 Class I

Angular, [0.25 to 1.5 inch](#), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

2.1.6.2 Class II

Coarse sands and gravels with maximum particle size of [1.5 inch](#), including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in [ASTM D2487](#).

2.1.6.3 Sand

Clean, coarse-grained sand classified as SW or SP by [ASTM D2487](#).

2.1.6.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as GW or GP in accordance with [ASTM D2487](#) . Do not exceed maximum particle size of [3 inches](#).

2.2 FLOWABLE FILL

Design and submit [flowable fill mix design](#) to consist of Portland cement, fly ash, and/or slag cement and fine aggregate. Include the dry weights of cementitious material(s); quality and gradation of aggregates in the saturated surface-dry weights along with gradation tests; quantities, types, and names of admixtures; and quantity of water per cubic yard. The unconfined compressive strength shall be [between 600 psi and 1,200 psi](#) at days in accordance with [ASTM D4832](#). The aggregates in accordance with [ASTM C33/C33M](#) Fine Aggregates. Air-entrain fill in accordance with [ASTM C260/C260M](#). The air content to be between 8 and 15 percent in accordance with [ASTM D6023](#). The flow to be [between 8 and 12 inches](#) in accordance with [ASTM D6103/D6103M](#). Portland cement to be Type I or II in accordance with [ASTM C150/C150M](#). Fly ash to be Class C in accordance with [ASTM C618](#). Provide slag cement in Grade 100 or 120 in accordance with [ASTM C989/C989M](#).

2.3 BURIED WARNING AND IDENTIFICATION MARKERS

Provide polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.3.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.3.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3.3 Detection Wire for Non-Metallic Piping

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG. Place wire above first soil lift above concrete encasement.

2.4 MATERIAL FOR RIP-RAP

Provide bedding material and rock conforming to GA DOT requirements for construction indicated.

2.4.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, or poorly graded with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than 6.

2.4.2 Grout

Provide durable grout composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one-part Portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air, as determined by the Contracting Officer. Mix grout in a concrete mixer. Allow a sufficient mixing time to produce a mixture having a consistency permitting gravity flow into the interstices of the riprap with limited spading and brooming.

2.4.3 Rock

Provide rock fragments which ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized such that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Provide rock with a minimum specific gravity of 2.50. Do not permit the inclusion of more than trace 1 percent quantities of dirt, sand, clay and rock fines.

2.5 BORROW

Provide borrow materials from sources located within and/or outside of Government property meeting the requirements of paragraph STRUCTURAL FILL.

2.6 GEOTEXTILE

Provide a pervious sheet of polyester, nylon, glass or polypropylene ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a non-raveling fabric with uniform thickness and strength. Fabric must have manufacturer certified minimum average roll properties that conform with approved design. Submit a sample and material product data for all Geotextiles utilized to the Savannah District soils section.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Contractor. The Contractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and provide temporary ditches, swales, and other drainage features and equipment as required to keep soils from becoming unstable, prevent erosion, or undermining of foundations. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Contractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.2.2 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches are not allowed within **3 feet** of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Perform control measures by the time the excavation reaches the water level in order to maintain the integrity of the in-situ material. While the excavation is open, maintain the water level continuously, at least **feet** below the working level.

3.1.3 Shoring and Sheet piling

Submit an **Excavation and Trenching Plan** to stabilize features, prevent undermining or unintended horizontal and vertical movement of adjacent structures, and prevent slippage or movement in banks or slopes adjacent to the excavation. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheet piling of excavations. Drawings to include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations are to include data and references used.

3.1.4 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.2 BORROW

Select borrow material to meet the requirements and conditions of the fill or embankment for which it is to be used. Obtain borrow material from [within the limits of the project site, selected by the Contractor from or from approved private sources](#). Submit a [Borrow Plan](#) that includes materials to be excavated, stockpile locations, proposed slopes, drainage, and closure. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval.

3.2.1 Contractor Furnished Borrow Area(s)

Obtain approved borrow materials from approved offsite sources. If a borrow source is selected that is not a commercial entity from which soil material is directly purchased, submit a Borrow Plan that includes the borrow source location, geotechnical test results showing the fill material meets the Contract requirements, environmental test results in accordance with paragraph ENVIRONMENTAL REQUIREMENTS FOR OFF-SITE SOIL, and any Federal, State, and local permits required for excavation and reclamation of the borrow area.

3.2.2 Environmental Requirements for Off-Site Soil

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity and reactivity. Backfill may not contain concentrations above appropriate State and EPA criteria, and for hazardous waste characteristics.

Determine TPH concentrations by using [EPA 600/4-79/020](#) Method 418.1. Determine BTEX concentrations by using [EPA SW-846.3-3](#) Method 5030/8020/8260B. Perform TCLP in accordance with [EPA SW-846.3-3](#) Method 1311. Perform hazardous waste characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide [borrow site testing](#) for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. Provide borrow site testing for hazardous waste characteristics (TPH, BTEX and TCLP) from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring borrow material to project site until Borrow Plan containing environmental test results has been received and approved by the Contracting Officer.

3.3 SURFACE PREPARATION

3.3.1 Clearing and Grubbing

Clear and grub as specified in Section [31 11 00](#) CLEARING AND GRUBBING.

3.3.2 Stripping

Strip site where indicated on the plans. Strip existing surface materials

to a depth of 4 inches below the existing ground surface in areas designated as Clear and Grub on the plans. Strip in all areas within the planned limits of disturbance. All stripped materials not suitable for reuse as topsoil will be wasted in specified disposal area. Screen all stripped soils to remove roots and organic materials prior disposal.

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Protect topsoil and keep in segregated piles until needed.

3.3.3 Proof Rolling

Perform proof rolling on exposed subgrade that is unfrozen and free of surface water (wet conditions resulting from rainfall).

After stripping, excavating, and rough grading to the planned elevation, proof roll the existing subgrade of all building, pavement and embankment locations with six passes of a loaded tandem axle dump truck. Operate the truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2.5 to 3.5 miles per hour. Subgrade materials that exhibit excessive deflection and/or rutting during proof rolling need to be improved as directed by the Contractors Geotechnical Engineer. When proof rolling under buildings, the building subgrade is considered to extend 5 feet beyond the building lines, and make one-half of the passes with the roller in a direction perpendicular to the other passes.

3.3.4 Stockpiling Operations

Place and grade stockpiles of satisfactory materials as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.4 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Excavate soil disturbed or weakened by Contractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes to minimize surplus material and to minimize additional material brought on site. Do not excavate below indicated depths except to remove unstable material as determined by the Geotechnical Engineer and confirmed by the Contracting Officer. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contracting Officer.

If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the

Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow sufficient time for classification and delineation of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

3.4.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown. Do not excavate below grades shown. Backfill excessive excavation as directed by the Contracting Officer, with satisfactory, compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed. Do not allow material to be deposited within **4 feet** from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.4.2 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended by the manufacturer. Provide vertical trench walls where no manufacturer installation instructions are available. Do not exceed the trench width of **24 inches** below the top pipe plus pipe outside diameter (O.D.) for pipes of less than **24 inches** inside diameter, and do not exceed **36 inches** plus pipe outside diameter for pipe sizes larger than **24 inches** inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.4.2.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of **inch** or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.4.2.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, notify the Contracting Officer. Following approval, remove such material **6 inches** below the required grade, **or as directed by the Geotechnical Engineer**, and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.4.2.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION.

When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.4.2.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown.

3.4.2.5 Gas Distribution

Excavate trenches to a depth that will provide a minimum 18 inches of cover in rock excavation and a minimum 24 inches of cover in other excavation.

3.4.2.6 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.4.3 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except those sections requested and if, in the opinion of the Contracting Officer, can be safely and properly installed and backfill. Provide a Jacking, Boring, and Tunneling Plan, signed and sealed by a licensed Professional Engineer that includes a work site layout, methods and procedures, equipment, alignment control, monitoring, and contingency for responding to unplanned movements.

3.4.4 Underground Utilities

Perform work adjacent to utilities in accordance with procedures outlined by utility owner. Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.4.5 Structural Excavation

Do not excavate to final grade until just before concrete is to be placed. Roughen level surfaces. Cut sloped surfaces as indicated into rough steps or benches to provide a satisfactory bond for compacting materials. For new pavement areas including exterior concrete pads, over-excavate to a minimum of 12 inches below bottom of new pavement/pad base course, scarify, moisture-condition, and compact to at least 95 percent of the Modified Proctor Density (ASTM 1557) and within 2 percent of optimum moisture content.

Make excavations to the lines, grades, and elevations shown, or as

directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata.

Concrete placement is not allowed until footing subgrades have been inspected and approved by the Contracting Officer.

3.4.6 Pile Cap Excavation

Stop the excavation at an elevation 6 to 12 inches above the bottom of the footing before driving piles. After pile driving has been completed, complete the remainder of the excavation to the elevations shown. After the pile driving has been completed, remove loose and displaced material and complete excavation, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry. Backfill and compact over-excavations and changes in grade due to pile driving operations to 95 percent of ASTM D1557 maximum density.

3.5 SUBGRADE PREPARATION

3.5.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in excavated areas, as determined by the Geotechnical Engineer. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill. Step or bench sloped surfaces steeper than 1 vertical to 4 horizontal prior to scarifying. Place 4 inches of loose fill and blend with scarified material. When subgrade is part fill and part excavation or natural ground, scarify to a depth of 8 inches.

3.5.2 Subgrade for Structures, Spread Footings, and Concrete Slabs

Do not excavate below depth shown for structures, spread footings, and concrete slabs. If over excavation occurs, notify the Contracting Officer and remove, replace, and compact as directed. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5.3 Subgrade for Railroads

Compact subgrade for railroads to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials.

3.5.4 Subgrade for Pavements

Compact top 12 inches of subgrade for pavements to at least 95 percent of ASTM D1557. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5.5 Subgrade for Shoulders

Compact the upper 6 inches of subgrade for shoulders to at least 95 percent of ASTM D1557 for the full depth of the shoulder.

3.5.6 Subgrade Filter Fabric

Place filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inch diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to plus or minus 3 percent of optimum moisture content. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.6.1 Trench Backfill

Backfill trenches to the grade shown. Do not backfill the trench until all specified tests are performed.

3.6.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.6.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.6.1.3 Bedding and Initial Backfill

Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except where shown or when specified otherwise in the individual piping section, provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact backfill to top of pipe to 85 percent of ASTM D1557. Provide plastic piping with bedding to spring line of pipe.

3.6.1.4 Final Backfill

Do not begin backfill until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Bring backfill to indicated finish grade. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation **2 feet** above sewer lines and **one foot** above other utility lines need to be free from stones larger than **one inch** in any dimension. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than **4 inches** in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.6.1.4.1 Buildings and Pavements

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction. Compact as specified for Structural Fill.

3.6.1.4.2 Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of **12 inches** loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.6.1.5 Heat Distribution System

Free initial backfill material of stones larger than **1/4 inch** in any dimension.

3.6.1.6 Electrical Distribution System

Provide a minimum cover of **24 inches** from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.6.1.7 Displacement of Features

After other required tests have been performed and the trench backfill compacted to the finished grade surface, inspect the pipe to determine whether unexpected or damaging displacement has occurred. Conduct walk-through inspection of pipe sizes larger than **48 inches**. Inspect pipes smaller than **48 inches** using remote methods using closed circuit television, sonar, or hybrid that can provide a 360-degree inspection of the pipe. Prepare and submit a **Pipe Inspection Report** consisting of digital video or photos. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the

defects as directed at no additional cost to the Government.

3.6.1.8 Buried Tape And Detection Wire

3.6.1.8.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape **12 inches** below finished grade; under pavements and slabs, bury tape **6 inches** below top of subgrade.

3.6.1.8.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed **12 inches** above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of **3 feet** of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.6.2 Structural Fill Placement

Place fill, **preload**, and backfill beneath and adjacent to structures in successive horizontal layers of loose material not more than **8 inches** in depth, or in loose layers not more than **4 inches** in depth when using hand-operated compaction equipment. Do not place over wet or frozen materials. Compact to at least 90 percent of laboratory maximum density for cohesive materials or 95 percent of laboratory maximum density for cohesionless materials, except as otherwise specified. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or other damage to the structure. Moisture condition fill and backfill material to within range of plus 2 or minus 2 percent of optimum moisture content at the time of compaction.

3.6.3 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.6.4 Porous Fill Placement

Provide under floor and area-way slabs on a compacted subgrade. Place in a single lift and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.6.5 Flowable Fill

Place fill in a manner to completely fill voids in the location indicated. Do not place when atmospheric temperatures are expected to be below **33 degrees F** at any time during the 3 day period following placement.

3.6.6 Compaction

3.6.6.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 85 percent of ASTM D1557.

3.6.6.2 Adjacent Areas

Compact areas within 5 feet of structures to 95 percent of ASTM D1557.

3.7 EMBANKMENTS

3.7.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise break up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Backfill and fill material are to be within the range of minus 2 to plus 2 percent of optimum moisture content.

Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.7.2 Preload and Surcharge Fills

Preload and surcharge fills shall extend at least 5 feet beyond the edge of the building perimeter. Preload and surcharge fills shall be monitored by installing settlement plates. Provide Settlement Monitoring Records to EN-GA weekly or as directed.

3.7.2.1 Settlement Monitoring

Where preloading or surcharging is utilized, settlement plates shall be installed on existing and prepared subgrades prior to fill placement and within 10 feet of vibrating wire piezometers. Obtain initial elevation readings. Obtain subsequent elevation readings as approved (at least weekly) until satisfactory settlements have been achieved. Reference Geotechnical Report dated March 2024 for settlement plate details.

Two (2) vibrating wire piezometers shall be installed, one near Boring B-1 (within the normally consolidated clay layer between El. -3.5 and -8.0 ft NAVD88 and one near Boring B-6 within the normally consolidated clay layer between El. -3.0 and -7.0 ft NAVD88. Record pore pressures hourly until fill is complete and four times daily thereafter until design settlements are achieved.

3.8 RIP-RAP CONSTRUCTION

Construct rip-rap on bedding material in accordance with Ga DOT standard in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.8.1 Bedding Placement

Spread bedding material uniformly to a thickness of at least 3 inches on prepared subgrade as indicated. Compaction of bedding is not required. Finish bedding to present even surface free from mounds and windrows.

3.8.2 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

For grouted rip-rap, hand-place surface rock with open joints to facilitate grouting and do not fill smaller spaces between surface rock with finer material. Provide at least one "weep hole" through grouted rip-rap for every 50 square feet of finished surface. Provide weep holes with columns of bedding material, 4 inches in diameter, extending up to the rip-rap surface without grout.

3.8.3 Grouting

Prior to grouting, wet rip-rap surfaces. Grout rip-rap in successive longitudinal strips, approximately 10 feet in width, commencing at the lowest strip and working up the slope. Distribute grout to place of final deposit and work into place between stones with brooms, spades, trowels, or vibrating equipment. Take precautions to prevent grout from penetrating bedding layer. Protect and cure surface for a minimum of 7 days.

3.9 FINISHING/FINISH OPERATIONS

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, frozen or otherwise unstable subgrade.

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except as indicated for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turbing materials. Repair graded,

topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.9.1 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.9.2 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.9.3 Shoulder Construction

Construct shoulders of satisfactory material. Submit advanced notice on shoulder construction for rigid pavements. Construct shoulders immediately after adjacent paving is complete. In the case of rigid pavements, do not construct shoulders until permission of the Contracting Officer has been obtained. Compact the entire shoulder area to at least the percentage of maximum density as specified in paragraph SUBGRADE PREPARATION above, for specific ranges of depth below the surface of the shoulder. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Finish shoulder construction in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. Align the completed shoulders true to grade and shaped to drain in conformity with the cross section shown.

3.9.4 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.9.5 Topsoil and Seed

Provide as specified in Section 32 92 19 SEEDING.

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of inches and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Remove from the site any surplus of topsoil from excavations and gradings. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas or as directed.

3.10 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property all surplus or other soil material not required or not suitable for filling or backfilling, along with brush, refuse, stumps, roots, and timber. Properly disposed of in accordance

with all applicable laws and regulations. Prepare plan for [Disposition of Surplus Materials](#) to include permissions document to dispose of nonsalable products.

3.11 TESTING

Perform testing as indicated in Table 1. Submit [Fill and Material Test Reports](#) within 7 days of tests being completed.

Material Type	Location of Material	Test Method	Test Frequency
Structural Fill Preload Fill Surcharge Fill		Density - ASTM D1556/D1556M ASTM D6938 ASTM D8167/D8167M . When ASTM D6938 or ASTM D8167/D8167M is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556/D1556M .	One test per 4000 feet , or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines. If ASTM D6938 or ASTM D8167/D8167M is used, check in-place densities by ASTM D1556/D1556M as follows: One check test per lift for every 10 tests. Where ASTM D8167/D8167M is used, provide water content verification in accordance with ASTM D2216 for each test.

Material Type	Location of Material	Test Method	Test Frequency
Structural Fill Preload Fill Surcharge Fill		Moisture Content - ASTM D2216	Two tests per day for each type of fill and backfill. Sample taken immediately prior to compaction after moisture conditioning.
Structural Fill Preload Fill Surcharge Fill		Moisture Density Relationship - ASTM D1557	One representative test when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.

Material Type	Location of Material	Test Method	Test Frequency
Structural Fill Preload Fill Surcharge Fill		Gradation - ASTM C136/C136M	One representative test when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.
Structural Fill Preload Fill Surcharge Fill		Atterberg Limits - ASTM D4318	One representative test when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.

-- End of Section --

SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING REPORT

SOF Consolidated Rigging Facility
FY-19, PN81905
Hunter Army Airfield, GA



By
Soils Section
Geotechnical & HTRW Branch
U.S. Army Engineer District, Savannah

March 2024

This report was prepared by the Savannah District of the U.S. Army Corps of Engineers. The initials or signatures and registration designation of individuals appear on these documents within the scope of their employment as required by the Engineer Regulation 1110-1-8152.

Nathan H. Bryan, P.E.
Geotechnical Engineer

Date: 04 March 2024

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SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING REPORT

SOF Consolidated Rigging Facility
FY-19, PN81905
Hunter Army Airfield, Georgia

1. PURPOSE

This report has been prepared for the design of the proposed SOF Consolidated Rigging Facility to be located at Hunter Army Airfield in Savannah, Georgia. The purpose of this report is to provide recommendations for the geotechnical and foundation design of the building and associated pavement.

The recommendations included in this report are based on the project information including the proposed finished floor elevation and maximum column loads, available in the Preliminary Design Submittal (35%) and Foundation Data Form 363.

Any change in site layout, structural system, loads, or finished floor or finished grade elevations may affect the recommendations. The Soils Section, Geotechnical, and HTRW Branch of the Savannah District should be notified immediately of the change(s) and provided the necessary information regarding any change(s) so that the new information can be reviewed. The recommendations in this report may then change as appropriate for the proposed project.

2. QUALIFICATION OF REPORT

The field exploration performed for this report was made to determine the subsurface soil and groundwater conditions and was not intended to serve as a comprehensive assessment of site environmental conditions. No effort was made to define, delineate, or designate any area of environmental concern or of contamination. Any recommendations regarding drainage and earthwork construction are made on the basis that such work can be performed in accordance with applicable laws pertaining to environmental contamination.

3. PROJECT DESCRIPTION

The project will consist of the design and construction of a consolidated parachute rigging facility in support of 1/75th Ranger Regiment and 3/160th Special Operations Aviation Regiment (SOAR).

Plans indicate a parachute drying tower packing lanes, parachute repair room, supply rooms, storage areas, oxygen systems maintenance room, and a classroom. The proposed rigging facility and attached drying tower will be structurally independent of each other and have a combined footprint of approximately 62,500-sf. Construction will consist of concrete foundation and floor slab with metal frame structure.

Other site improvements are to include utilities, lighting, vehicle parking, access drives, curb and gutter, sidewalks (5,000-sf), storm drainage, landscaping, and roads. Approximately 70,000-sf of concrete driveway/hardstand and 17,500-sf of asphalt pavement are planned.

Based on provided drawings, the planned finish floor elevation (F.F.E.) will be at El. 19-ft NAVD88, resulting in fill heights varying from about 2 to 6½ feet within the main building area and varying from about 5 to 6½ feet within the tower area. Fill heights in asphalt and concrete pavement areas will be on the order of 2 to 3 feet. Fill slopes adjacent the buildings will be 4H:1V or flatter. Figures 1 and 2 present a plan view of the project and proposed site grading.

3.1 Main Building and Cargo Pack Lane

The main building of the rigging facility will be a concrete masonry unit (cmu) structure with a footprint of approximately 276-ft x 225-ft. The gable roof will vary from ~20-ft eave height to a 40-ft ridge. In addition to the cmu bearing walls, interior steel beams and columns support the gravity load consisting of roof dead, roof live, and the self-weight of the structure. Wind and seismic loads are resisted by cmu shear walls.

The envelope of the cargo pack lane will be comprised of non-loadbearing cmu, with an overall building footprint of 37-ft wide by 165-ft long. The maximum roof height will be approximately 40-ft. The primary structure of the cargo pack lane consists of steel framing to support an interior, double-girder bridge crane with a rated capacity of 25 tons. In addition to the rated capacity of the crane, the framing must support the crane girders, trolley, and hoist, which are estimated to weigh a combined 50 kips of dead load.

For the main building, maximum sustained loads are estimated to be on the order of 70-kips and 6.5-klf for isolated column and wall foundations, respectively. Within the cargo pack lane, estimated column loads will be a function of crane location as indicated below:

- Max. sustained (worst case, crane parked on column line, crane unloaded) = 72 kips
- Max. extreme, vertical (crane operating loaded) = 130 kips vertical, and 9 kips lateral from side thrust
- Max. extreme, lateral (wind, seismic) = 100 kips vertical, 14-kips lateral

Conventional floor slab loads are estimated to be 125 and 250 psf in the HVAC equipment rooms and carpentry shop, respectively. In remainder areas, floor slab loads are estimated to be 100 psf.

3.2 Parachute Drying Tower

The drying tower will be a 100-ft tall, steel braced-frame structure with an approx. 40-ft x 35-ft footprint. The live loads at the foundation are predominantly attributed to the various arrangements of wet parachutes suspended from the mezzanine level.

Assuming the tower loads are supported at each corner only, maximum isolated column loads (for axial bearing) are estimated to be 301-kips and 430-kips during static and extreme (hurricane) loading events, respectively. During the extreme event, a concurrent lateral load of 60-kips is estimated. Worst case lateral and axial uplift, during an extreme event, are -124 and 80 kips, respectively.

4. EXPLORATION PROCEDURES

4.1 Site Reconnaissance

Prior to the field exploration, the proposed project site and surrounding areas were visually inspected by a geotechnical engineer. The observations were used in planning the exploration, in determining areas of special interest, and in relating site conditions to known geologic conditions in the area.

4.2 Field Exploration

The subsurface exploration consisted of eight (8) standard penetration test (SPT) borings and two (2) cone penetration test (CPTu) soundings. During CPT testing, geophone sensors were placed near the cone tip to measure the magnitude and arrival time of seismic shear and compression waves generated at the soil surface.

The boring/CPTu sounding locations are shown in Figure 1 –Exploration Location Plan contained in Appendix A. Corresponding boring logs and soil profiles are contained in Appendix A. Ground surface elevations were interpolated from provided topographic drawings.

4.2.1 Standard Penetration Tests (SPT)

Borings B-6 and B-7 were drilled by mechanically twisting a continuous flight hollow stem steel auger into the soil. Borings B-1 through B-5 and B-8 were made by a rotary wash drilling procedure in which drilling mud was maintained in the borehole to stabilize the borehole walls and to flush the soil cuttings to the surface. To avoid damage to a reported sewer pipe, boring B-4 was initially advanced 8 feet bgs using hand auger equipment. Soil cuttings recovered in the hand auger were visually classified.

Standard penetration testing was performed in general accordance with ASTM D1586. At assigned intervals, soil samples were obtained with standard 1.4-inch I.D., 2-inch O.D., split-tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, and then driven an additional 12 inches with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final 12 inches was recorded and is designated the “penetration resistance”. The penetration resistance, when properly evaluated, is an index to the strength of the soil and foundation supporting capability. For gravelly and fine-grained soils, SPT can be unreliable for obtaining strength and stiffness properties. In several instances, blow counts could not be obtained due to the drill string (drilling rod and split-spoon sampler) sinking under the static weight of the hammer (WOH) or the weight of the rods (WOR) alone. These events generally reflect very weak soils, voids, or excessive weight of drill string. These events are denoted on the respective boring logs and a value of $N_m = 0$ bpf was assigned.

A CME and Diedrich automatic SPT hammer were used to advance the split-barrel samplers in the SPT borings. A significantly greater efficiency is achieved with the automatic hammers as compared to conventional safety hammers operated with a cathead and rope. For each of the automatic hammers used, the respective drill rod energy ratio (ERi) is denoted on the boring logs.

Disturbed SPT samples were obtained during drilling at test intervals. Adjacent to select soil borings (B-1 and B-5), relatively undisturbed samples were also obtained using a 3 in. OD Shelby tube in general accordance with ASTM 1587. A summary of the locations and undisturbed laboratory soil test results are discussed in Section 4.3 Laboratory Soil Testing and the corresponding test results are provided in Appendix B.

Classification of the soil samples was performed in general accordance with ASTM D 2488 (Visual-Manual Procedure for Description of Soils). The soil classifications include the use of the Unified Soil Classification System described in ASTM D2487 (Classification of Soils for Engineering Purposes). Since the soil descriptions and classifications are based on visual examination and laboratory testing, they should be considered approximate.

Where encountered, depth to groundwater is denoted on the boring logs. Due to the introduction of water for borehole stabilization in the mud-rotary borings (B-1 through B-5, and B-8), long-term water levels could not be obtained.

4.2.2 CPTu Soundings

The Cone Penetration Test (CPTu) soundings (CPT-1 and CPT-2) were performed in general accordance with the procedures outlined in ASTM D5778. A Vertek track mounted rig was utilized by USACE Savannah District to perform the CPT soundings. Soil samples were not obtained.

The soundings were performed by hydraulically pushing a 10 sq. cm. electric cone at two-centimeter intervals (approximately 1 inch) per second. The cone shaped tip of the cylindrical probe is equipped with electronic sensors consisting of load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure pore pressure. Based on published empirical relationships, the measured data was used to derive stratigraphic profiles and to estimate soil engineering properties including soil modulus, shear strength, and relative density. The standard piezocone parameters (q_c , f_s , and u_2), are presented in graphical and tabular form in Appendix A. Also, for each cpt sounding, the soil behavior type as a function of the normalized cone resistance and friction ratio is presented (Robertson, 1986).

4.2.3 Shear-Wave Velocity Measurements

At both CPT locations, a single geophone (pseudo-interval downhole method) was utilized to measure the shear wave velocity at each one-meter rod break. Results of downhole shear wave velocity measurements are contained in and presented graphically in Appendix A.

In addition to the downhole shear wave velocity measurements, shear wave velocity measurements were also estimated utilizing Refraction Microtremor (ReMi) surface arrays. Geophysical survey data was processed using SeisOpt software developed by Optim. Seismic data were collected using a DAQLink 24-bit signal processing seismograph using twenty-four 10-Hz geophones. Array length was 240-lf.

4.2.4 Soil Percolation Testing

Three shallow hand augers (P-1, P-2, and P-3) were drilled for the purposes of soil percolation testing in accordance with DM 110-1-1. Test locations are denoted on Figure 1.

4.3 Laboratory Soils Testing

Laboratory soils testing was completed by the Savannah District Engineers Materials and Instrumentation Unit (EMU). Soil samples were visually inspected and assigned a Unified Soil Classification System (USCS) classification by an experienced laboratory technician. Index properties of samples representative of soil stratification were determined by performing mechanical sieve analysis, Atterberg limits, and in situ water contents.

One-dimensional consolidation tests were also completed on three (3) relatively undisturbed Shelby samples to evaluate the compressibility characteristics of the underlying cohesive materials. Testing was performed in accordance with ASTM D4186 and included time rate of consolidation curves. More Laboratory test results are located in Appendix B and summary results of the one-dimensional consolidation test results summarized in Table 4-1.

Table 4-1. Summary of Soil Consolidation Testing

Soil Consolidation Parameters	B-1 5-ft Depth	B-1 19-ft Depth	B-5 9-ft Depth
Dry unit weight, pcf	86.2	77.0	97.2
Natural moisture content,	33.4	39.0	26.2
Initial void ratio, e_o	0.920	1.148	0.702
Compression index, C_c	0.163	0.355	0.138
Compression ratio, $C_c/(1+e_o)$	0.085	0.165	0.081
Recompression index, C_r	0.048	0.035	0.051
Recompression ratio, $C_r/(1+e_o)$	0.025	0.016	0.030
Coefficient of Consolidation (C_v), ft ² /day	0.018 ¹	0.25 to 0.78 ²	0.013 to 0.019
Over Consolidation Ratio, OCR	6.1	1.1	1.3
Maximum Preconsolidation Pressure (σ'_p), psf	3,500	1,600	1,330

1. In the range of recompression.

2. In the range of virgin consolidation. Sample was classified as clayey sand (SC), fines content of 49%.

5. SITE AND SUBSURFACE CONDITIONS

5.1 Site Description

The site is located at the Hunter Army Airfield located in Savannah, Georgia near Lat: 32.0062, Long: -81.17187. The proposed facility will have a footprint approximately 62,500-sf and be located in a partially wooded and partially improved area southwest of the exiting airfield. The site is in close proximity to the Little Ogeechee River with surficial soils consistent with older marsh deposits. A small portion of the site outside of the planned building area incorporates paved drive and parking areas.

5.2 Area Geology and Regional Seismicity

Hunter Army Airfield is located in the Coastal Plain geologic physiographic province, which in the state of Georgia encompasses the areas south of the Fall Line (the demarcation separating the Coastal Plain from the Piedmont province). The surface of the Coastal Plain can be described as a flat to slightly undulating topography. The geology is characterized by sedimentary formations which are Cretaceous in age or younger, and which dip gently to the south.

Review of the boring data and available geologic maps (Rado et. al, 1986) suggest the site is underlain by the reported Silver Bluff Back-Barrier Complex, which is a younger (Holocene) aged formation which reportedly predominates the nearby marsh areas. These marshland sediments consist primarily of river- and tide-borne sands, silts, and clays. When saturated, these cohesionless deposits are often highly susceptible to seismic liquefaction. These younger deposits are reportedly underlain by the Pamlico Shoreline Complex, marsh and lagoonal facies (Pleistocene age).

The project site is located within the Central and Eastern United States (CEUS) seismic region. The seismic zone currently identified by the United States Geological Survey (USGS) that may contribute to ground shaking at this site is the South Carolina Seismic Zone (SCSZ) in the Charleston/Coastal area. The SCSZ is considered the dominant seismic source for this site given the low magnitude, and/or long recurrence interval for earthquakes from other sources.

Talwani and Schaeffer (2001) used evidence from previous earthquakes to determine how often earthquakes like the 1886 earthquake have occurred in the Charleston/Coastal area. They determined that earthquakes in the Charleston area appear to occur about every 400-500 years and there is a possibility that large earthquakes may occur in Georgetown and Bluffton on ~2,000-year cycles. Unfortunately, their data set is limited to only the last 6,000 years because of changes in groundwater levels which affect the formation of earthquake features. Thus, it seems that it is unlikely that a large earthquake will occur soon at the subject property, however, statistically there is a 1/400 chance that a large earthquake will occur each year. Smaller (<6.0 magnitude) earthquakes don't tend to leave much evidence behind for scientists to find later, so it is unclear how often these occur in this area.

Review of the deaggregated 2018 USGS NSHM ground motion data for a 2% probability of exceedance in 50 years confirms that the SCSZ may contribute to strong ground shaking at this site with modal values of magnitude and source-to-site distance reported as M7.3 and R = 57 miles, respectively. Refer to Appendix D for the USGS Deaggregation Summary.

5.3 Subsurface Soil Conditions

Surficial soils typically contain root mat and/or fibrous organic matter. Surficial soils with trace organics was encountered at the site to depths as great as approximately 2 ft bgs.

Possible Fill

Possible fill was encountered in SPT borings B-3, B-4 through B-7 to depths as great as 5 feet below existing ground surface. The possible fill was sampled as fine silty sand or sand with little silt. SPT N-values in the fill varied from 5 to 24 blows per foot (bpf). Historical documents relating to earthwork at this site could not be located.

Stratum 1 – Holocene Interbedded Clay and Sand

Interbedded clay and sand (USCS CH, SC, CL, SP, SP-SM soil types) were encountered in the SPT and CPT soundings to depths as great as 35 feet below existing ground surface. The upper clay (USCS CH, CL type soils) are generally characterized as moderately overconsolidated. The lower clay layer is characterized as normally consolidated, having an OCR ~1.0, with moisture contents commonly at or above the respective liquid limit of the soil. Percent fines in the lower clay layer varied from ~50 to 80 percent.

Very loose, loose, and occasionally medium dense sand (USCS, SC, SP, SP-SM, SW soil types) were generally encountered between ~ El. 10 to -15-ft NAVD88. Fines content within the upper sands varied from about 4 to 38 percent.

Stratum 2 – Pleistocene Sands

Underlying the interbedded clay and sand below ~El. 15-ft NAVD, reddish brown medium dense sand (USCS SP-SC, SP-SM, SM soil types) were encountered in the deeper soil test borings and cpt soundings to depths as great as 50 ft bgs or boring termination (where shallower). Fines content within the lower sands generally varied from about 7.3 to 34 percent.

Stratum 3 – Miocene Silty Sand (Marl)

In the deeper soil test boring B-1, greenish gray fine to medium silty sand with few shell fragments was encountered from ~50-ft bgs to boring termination (~75-ft bgs).

5.4 Groundwater Conditions

5.4.1 Groundwater Depths

Groundwater was encountered at depths in the range of about 5 to 11½ feet bgs during and after drilling activities; corresponding to an approximate groundwater elevation of between 3 and 8½ ft NAVD88 during drilling. At boring B-1, a temporary observation well (slotted pvc pipe) was installed. Groundwater level in B-1 after a period of 24 hours was measured at a depth of 5-ft below existing site grades.

In addition, perched water could develop in sand seams and above lower permeability clayey soils following periods of heavy or prolonged precipitation. A perched-water condition occurs when water seeping downward is slowed by a low permeability soil layer, such as silt or clay, and saturates the more permeable soil above it. The perched-water level can be any number of feet above the true groundwater level. Due to the prevalence of interbedded sand and clays at the project site, the successful design-build contractor should expect to encounter perched water during construction.

Fluctuations in the elevation of the groundwater should be anticipated with changing climatic and rainfall conditions. It is expected that groundwater depths at the site will be influenced by local tidal activity. Therefore, water levels during construction at other times in the life of the project may be higher or lower than the levels indicated on the boring logs. The possibility of water level fluctuations should be considered when developing the design and construction plans for the project.

5.4.2 Soil Infiltration Properties

Soil permeability information for infiltration rate determination was obtained from three (3) borehole percolation tests (PT-1 through PT-3) performed at the locations shown on the Exploration Location Plan in Appendix A. The percolation tests were performed in accordance with USACE SAD DM 110-1-1 July 1983 chapter 20. The percolation rates from the field tests were used to estimate infiltration rates using the LID Manual for Michigan-Appendix E, Soil Infiltration Testing Protocol.

Table 5-1. Summary of Soil Infiltration Rates

Test Location (percolation test depth range)	Soil Classification	Percolation Rate, in./hr.	Infiltration Rate ¹ , in.hr.	Average Water Head, in
P-1 (0 – 4.5 ft)	Sandy Clay	0.24	0.01	6.0
P-2 (0 – 1 ft)	Sandy Clay	0.72	0.05	6.0
P-3 (0 – 1 ft)	Sandy Clay	0.12	0.005	6.0

1. If proposed infiltration system will mainly rely on vertical downward seepage, the corrected infiltration rates should be used. The corrected infiltration rates were calculated using the xx method.

The Michigan method uses an area reduction factor (R_f) to account for the exfiltration occurring through the sides of a percolation hole. It assumes that the percolation rate is affected by the depth of water in the hole and that the percolating surface of the hole is in uniform soil. The Michigan method could thus be used to convert soil percolation rates to infiltration rates as indicated in Table 5-1.

$$\text{infiltration rate} = \frac{\text{percolation rate}}{\text{reduction factor}}$$

where, reduction factor (R_f) is given by:

$$R_f = \frac{2d_1 - \Delta d}{DIA} + 1$$

And:

d_1 = initial water depth (in.)

Δd = average/final water level drop (in.)

DIA = diameter of the percolation hole (in.)

Field infiltration rates represent the result of our tests at the depths and locations indicated, as described above. The design infiltration rate should be determined by the designer by applying an appropriate factor of safety. The actual infiltration rate may vary from the values reported herein. Infiltration systems should be located a minimum of 50 feet from any existing or proposed foundation system

6. ENGINEERING RECOMMENDATIONS

6.1 Geotechnical Considerations

There are three primary geotechnical related concerns at this site, which will affect the performance of building foundations and site grading. The following summarizes those concerns.

1. The site is underlain by a very soft marine clay that will consolidate under new fill and building loads. The new fill/building loads are estimated to result in intolerable long-term total and differential settlement of building structures. To achieve site grades, fill heights of ~2 to 6½ feet will be necessary across the building pad with lesser fills (~2 to 3 feet) needed in pavement areas.

Beneath the building structures, total settlements due to the new fill alone are estimated to be on the order of ½ to 4 inches. Time rate of consolidation estimates indicate the new surface loads will require weeks to months to consolidate the underlying foundation soils with tolerable settlements remaining. However, time rates could vary significantly due to variable soil types/permeability and drainage conditions. Measures to limit total and differential settlements and improve and provide competent bearing conditions are discussed in Sections 6.2 and 6.3. Site relocation is not addressed in this report due to concerns expressed by PM regarding cost and schedule impacts.

2. Soft and loose soil deposits were encountered to depths as great as ~30-ft bgs at the site and exhibit a high probability to liquefy during the design earthquake. For the drying tower, ground improvement (e.g., stone columns, aggregate piers) or improved drainage (e.g., earthquake drains) will be necessary to densify loose soils or limit excess pore pressures that could trigger seismic liquefaction for the design earthquake. For the main building, the foundation recommendations presented in this report for static loads are sufficient to limit differential settlements during the design earthquake to tolerable levels for the purposes of life safety in accordance with the requirements of ASCE 7-16. However, some loss of serviceability could result during seismically induced liquefaction.
3. The upper clayey soils at this site are expected to be more improved with lower moisture content near the surface and within the upper few feet. Where this surficial stratum 'crust' is removed/stripped and/or becomes wet or saturated during construction and/or subjected to repeated construction loadings, severe pumping and/or rutting could occur. We recommend the upper, surficial layer, where containing less than 5% organics, should not be stripped during site grading. We also recommend low contact pressure 'tracked' construction equipment be utilized at this site during construction.

It is imperative that the contractor maintain positive surface drainage during construction due to the moisture susceptibility of the subgrade soils. Where feasible, we recommend grading activities be scheduled for the drier months to reduce the potential for construction problems associated with wet soils. The stability of the subgrade soils for pavement support, and therefore the amount of stabilization and/or undercut required, will be directly related to stripping depths, moisture conditions, and exposure to equipment loadings during construction.

6.2 Ground Improvement

The building and tower structures, where constructed over newly placed fill, will undergo excessive long-term consolidation settlement. The building structures can be supported on shallow foundations bearing on improved ground (designed by others) as outlined in this report. Deep foundations are not considered practical as they would not address settlements associated with the floor slabs unless structurally supported.

6.2.1 Main Building

For shallow foundation support, ground improvement will be necessary. Feasible ground improvement options are discussed below.

6.2.1.1 Pre-Loading and Settlement Monitoring

Post construction settlements under long-term sustained loads can be mitigated by implementing a fill pre-loading program. This would entail raising site grades to finish floor elevation (FFE = 19-ft NAVD88), followed by placing a surcharge fill pad above finish floor elevation to induce settlements prior to application of building loads. Although a pre-load program will mitigate settlements under static loads, as noted above, the potential for some loss of serviceability and distortion resulting from seismically induced liquefaction settlement would remain.

Pre-loading allows settlements (associated with a design fill and surcharge) time to occur prior to building construction, such that final settlements associated solely with the building structure will fall within allowable tolerances. The higher the surcharge load, the faster consolidation settlements would be expected to occur. The surcharge fill does not need to meet any special requirements other than having a minimum in-place moist unit weight of 115 pounds per cubic foot (pcf). Loosely dumped soils are unlikely to achieve this density and therefore compaction control should be anticipated.

Various configurations of surcharge fill heights and drainage can be implemented; however, the surcharge fill should extend a minimum of 5 feet beyond the edge of the perimeter building footings. Depending on fill height a duration of 2 to 4 months is typically sufficient.

To verify the amount of settlement and the time rate of movement, the pre-load program should be monitored by installing settlement plates. The settlement plates should be installed on the existing and prepared subgrade prior to placing fill and within approved areas. Once installed, elevations of both the fill height and settlement plate should be surveyed daily until the full height of the surcharge is in place. Once fully surcharged, readings should continue weekly until the anticipated settlements have occurred. A typical settlement plate detail is provided in Appendix C.

Where surcharging will serve as the sole method of settlement mitigation, a vibrating wire piezometer capable of numerous daily recorded readings should also be installed within the northeast corner of the main building pad near boring B-1. The piezometer should be installed between elevation El. 17 and 21½ ft NAVD88, within the normally consolidated clay strata. All monitoring data should be forwarded to us within two days after it is obtained for review and comment.

It is critical that the grading contractor recognize the importance of the settlement plate installations as they are commonly destroyed during construction. Settlement devices must be protected from damage during fill placement. It is difficult, if not impossible, to evaluate the progress of the preload/surcharge program if the markers are damaged or destroyed by construction equipment.

If the markers are impacted, it may be necessary to install new markers and extend the surcharging duration to determine if settlements have ceased and building construction can begin. After fill-induced settlements have been reduced to tolerable levels, vertical construction may proceed. Preloading can be used independently or in conjunction with other methods. Since the project must be completed within the performance period, alternative measures (e.g., stone columns, aggregate piers) may also be necessary and can be utilized for foundation support.

6.2.1.2 Load Transfer Platform (Main Building Support)

Ground improvement by load transfer platform (LTP) may be used for support of the main building foundations and grade slab where preloading is not feasible due to time constraints. Various LTP configurations are possible and will require design by others. The purpose of a Load Transfer Platform (LTP) is to transfer loads from the building foundation, grade slab, and fill embankment to a firm stratum via subsurface columns.

There are numerous types of columns that may be used for this technology (e.g., stone columns, rammed aggregate piers, rigid inclusions, driven piles). A load transfer platform or bridging layer is constructed immediately above the columns to help transfer the load of the fill and building to the columns, and thereby permit larger spacing between columns than would be possible otherwise. Bridging layers generally consist of soil and gravel fill reinforced with geosynthetics. The reinforced soil/aggregate mass acts as a beam or 'platform' to transfer the load from the building/structural fill above the platform to the columns below. A minimum of three layers of reinforcement are typically used to create the platform. Platform thickness is generally greater than or equal to one-half the clear span between columns; however, may vary between foundation and grade slab areas.

LTP's must be designed to support the entire building with finish floor elevation (FFE = 19-ft NAVD88) and any grade raise fill that could result in intolerable building settlements. The platform should extend at least 10 feet north of the building to allow for more tolerable settlements near the building entrance. Structural fill placed above the LTP should be compacted to 92% of the modified Proctor maximum dry density and placed on a properly prepared subgrade.

Where not preloaded, exterior unsupported areas immediately adjacent the building (e.g., sidewalks, door entrances) could require additional repairs (e.g., sidewalk replacement/repair) once tolerable consolidation settlements remain. Inspection of site grades near the building would be necessary after a period of 3 to 5 years.

6.3 Shallow Foundations

6.3.1 Shallow Spread Footings (Main Building)

With implementation of ground improvements, the main building can be supported by spread foundations bearing on improved ground or compacted structural fill overlying improved ground. For preliminary design, we recommend shallow spread foundations be proportioned for a net allowable bearing pressure of 2,000 psf.

Minimum widths for individual column and continuous wall footings should be 30 and 18 inches, respectively. The minimum widths are considered advisable to provide a margin of safety against a local or punching shear failure of the foundation soils. Foundations should bear at least 12 inches below final exterior grade and finished floor elevation to provide frost protection and protective embedment (for exterior footings).

Ground improvement should be implemented and limit total static settlements to less than 1-inch. Differential static settlements should be ½ inch between supports and less than ½ inch over 30-ft for wall footings. Mitigation of liquefaction-induced settlement is not required.

6.3.2 Mat Foundation (Drying Tower)

A mat foundation placed on improved ground (e.g., preload with stone columns, vibroproiers, rigid inclusions) can be utilized for drying tower structure. Liquefaction mitigation within and around the drying tower footprint will also be required as discussed in Section 6.4.2.1.

For preliminary design, we recommend a net allowable bearing pressure of 1,500 psf based on dead plus long-term live loads. A subgrade modulus of 15 lb/in²/in can also be utilized in preliminary design. Final values should be confirmed by the ground improvement contractor. Ground improvements should account for static and extreme downloads induced by the tower and limit total settlements to less than 1-inch. Differential settlements across the tower structure should be less than ½-in over 30 feet.

The bearing depth and size of the mat should be controlled by the load requirements necessary to resist the overturning moment induced by wind loading. However, the mat should bear no shallower than 4 feet below proposed site grade. Uplift on the mat foundation can be resisted by the weight of the mat, the weight of the structure, and any soil overlying the mat. A soil unit weight of 120 pounds per cubic foot (pcf) may be assumed for select fill placed above the mat, provided the select fill is properly compacted as recommended in this report. Criteria for select fill are discussed in Section 6.5.2. If necessary, a lip can be added to the base to increase the resistance to uplift. An ultimate coefficient of friction across the mat foundation base of 0.4 can be used to aid in the resistance of ground line shear.

If the mat foundation is over-excavated and formed, the backfill around the foundation sides should consist of flowable fill or lean concrete. Steel should be placed, inspected, and the foundation poured the same day of excavation. Bearing surfaces should remain free of surface runoff water.

6.4 Settlement Analyses

6.4.1 Total and Consolidation Settlement

Project plans indicate fill heights across the building pad will vary from ~2 to 6½ feet. Settlement analyses were performed at multiple locations within the building areas to estimate the settlement of the foundation soils. Table 6-1 summarizes our settlement analyses performed for the main building and tower area based on proposed fill heights alone without ground improvements.

Settlement parameters were estimated for the foundation soils based on the results of the laboratory and in-situ soil data. We estimated consolidation parameters for the clay type soils using results of laboratory oedometer testing. Settlement parameters for the granular (non-cohesive) materials were estimated based on energy corrected SPT $N_{1,60}$ -values correlated with laboratory classification testing, and relative densities. Constrained modulus values were also estimated from CPT soundings for both sand and clays.

Table 6-1. Summary of Total Settlement (Fill Only)

Location	Fill Height (ft)	Estimated Settlement ¹		
		Clay Foundation Soils (in.)	Sand Foundation Soils (in.)	Total (in)
CPT-1	6.0	3.8	0.1	3.9
B-1	6.0	3.1	0.5	3.6
B-2	6.5	2.5	0.7	3.2
B-3	2.0	1.0	0.2	1.2
B-4	6.5	2.9	0.4	3.2
B-5	2.0	1.2	0	1.2
B-6	4.5	2.0	1.2	3.1
B-8	4.5	0.8	0.9	1.8
CPT-2	2.0	0.3	0.1	0.4

1. Does not consider settlements from building loads or seismic liquefaction.
2. Time rate of consolidation could vary significantly across the building pad due to highly variable fines content in the normally consolidated clay / clayey sand layer, which varies from about 25 to 73 percent.

For unimproved ground and assuming a foundation contact stress of 2,000 psf for spread footings, consolidation settlements within the main building area are estimated to be on the order of 4.5 inches near CPT-1 about 1.0 inch near CPT-2. Where similarly supported on unimproved ground, and assuming a foundation contact stress of 1,500 psf, total and long-term consolidation settlements below the tower structure are estimated be on the order of 10 and 8 inches, respectively.

6.4.2 Seismic Liquefaction Settlement

Soil liquefaction is the sudden reduction in shear strength of saturated cohesionless soils caused by external loading, which induces high excess pore water pressures in soils. Soils most susceptible to liquefaction are saturated, loose, fine sands with low fines (e.g., silt/clay) content. However, soils with greater fines contents also have the potential to liquefy during an earthquake.

Liquefaction features produced by the large 1886 Charleston Earthquake are most heavily concentrated within the meizoseismal ‘maximum damage area’; however, are reported as far away from Charleston as Columbia and Bluffton, SC and well within the limits of the project site. Soils susceptible to seismic liquefaction were encountered in the CPTu soundings and deeper SPT borings at depths between about 6 and 35 feet below existing ground surface. Liquefaction susceptibility is attributed to these sandy, and relatively laterally continuous Holocene sediments that predominate the upper portion of the site and overlie the aged Pleistocene deposits and marl.

We performed a site-specific liquefaction analysis using empirical methods based on Seed and Idriss and subsequently modified by others. Liquefaction was evaluated for the MCE_G ground motion assuming a groundwater depth of 5-ft below existing grades. Liquefaction triggering analyses were performed using empirical methods based on Seed and Idriss and subsequently modified by others. The latest recommended procedures include Idriss and Boulanger (2004, 2014), Moss (2006), Robertson and Wride (1997). Results of the triggering analyses suggest the probability of soil liquefaction at the site is ‘almost certain’ (Juang et. al, 2002). We did not evaluate lateral spreading at the site because the ground surface is relatively level and the distance to a free face exceeds that of past earthquakes where lateral spreading was observed.

Post-liquefaction settlements at the site are estimated to be on the order of 4½ to 5½ inches using appropriate correlations between cyclic stress and liquefaction resistance. For our analyses, we assumed an overburdens stress equivalent to the average fill height of 4½ feet within the planned building areas.

Published information indicates that the site will not experience surface liquefaction effects (e.g., sand boils, surface fissures) for shaking that does not equal or exceed 0.3g. As previously stated, the site modified peak ground acceleration, PGA_M is 0.231g. It is possible that site-specific site response analyses and/or site-specific seismic hazard analyses would result in a different surface acceleration. Site-specific response analyses and/or site-specific seismic hazard analyses are not addressed this report..

6.4.2.1 Liquefaction Mitigation

It is understood that the building structures are categorized as Risk Category II (non-essential). For our evaluation of possible mitigation measures, we considered support of the building due to static loading conditions and the potential hazards associated with the detrimental effects of soil liquefaction during an extreme event.

Main Building: For short (stiff) structures such as the main building having a fundamental period, T_o less than 0.5s, liquefaction is not expected to significantly affect spectral response and improvements to mitigate liquefaction are not necessary to meet code requirements.

Drying Tower: For the taller drying tower ($T_o > 0.5s$) spectral response and bearing conditions could be negatively impacted by seismic liquefaction. Therefore, we recommend ground improvements (e.g., earthquake drains, vibro-replacement). The mitigation area should extend approximately 20-feet from the building limits as shown in Figure 2, which assumes a projection limit of approximately 35 degrees from the lowest identified liquefiable layer.

Earthquake drains or stone columns (where designed to reduce excess seismic pore pressures), should limit excess pore pressures generated in the foundation soils during seismic events to levels less than those that could trigger liquefaction. Stone columns (e.g., vibro-replacement/compaction stone columns), where designed to densify foundation soils, should provide a factor of safety against liquefaction greater than 1.15. Alternatively, mitigation could be designed to 1) meet a combined static and liquefaction induced differential settlement, angular distortion, $\beta = 1/500$ or less, and 2) post-construction total settlement of less than 1 inch.

Earthquake drains alone are not considered sufficient to reduce static settlements to tolerable amounts; however, installation of these drains in addition to ground improvement (e.g., stone columns, rigid inclusions) under a mat foundation could reduce static settlements to tolerable levels and or improve the performance of the structure during a seismic event.

6.5 Earthwork

6.5.1 Site Preparation

We anticipate that construction will be initiated by removal of trees, utilities, and pavements. These materials should be removed from the entire construction area. Surficial soils having more than 5% organics should also be removed from structure and pavement areas.

Once clearing, grubbing, and stripping is complete, structure and pavement areas should be proofrolled. The proofroll should be observed by a geotechnical engineer to determine the existence of any areas of excessive rutting or deflection within the proposed building or pavement areas. The proofroll should be performed prior to placement of approved engineered fill.

The clayey surficial soils encountered at this site are susceptible to disturbance from construction activity. Although the exposed soils may be relatively stable upon initial exposure, unstable subgrade conditions could develop during general grading activities; particularly if the soils are wetted and/or subjected to repetitive construction traffic. Due to the moisture susceptibility of the on-site soils and potential for severe loss of subgrade support, it is imperative that the contractor maintain positive surface drainage during construction.

We recommend heavy equipment traffic bearing directly on bearing surfaces be avoided (where possible), or limited to low contact pressure equipment (e.g. track mounted equipment). Should unstable conditions be revealed during proofrolling or develop during grading, some form of stabilization could be required. More specific recommendations can be provided during construction, as the subgrade conditions are exposed, but such recommendations could possibly include removal and replacement with engineered fill or other measures such as:

- **Scarification and Recomaction** – It may be feasible to scarify, dry, and recompact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Even with adequate time and weather, stable subgrades may not be achievable if the thickness of the soft soil is excessive.
- **Lime or Cement Modification** – The use chemical media (e.g., cement, lime) can be added to the soil. For clays, the soil dries, making the soil less susceptible to changes in water content. When at depth, excavation/treatment and replacement with engineered or treated in-situ soil can be considered.

6.5.2 Structural Fill

Structural fill shall meet the requirements of the load transfer platform design for the main building. For remainder areas, materials selected for use as structural fill should be free from roots and other organic matter, trash, debris, frozen soil, and stones larger than 3 inches in any dimension, and in general, should have a liquid limit less than 50 percent and a plasticity index of less than 30.

The following soils represented by their Unified Soil Classification System (ASTM D 2487) group symbols will be suitable for use as structural fill: GP, GW, GC, GM, SP, SP-SM, SP-SC, SW, SC, SM, SM-SC, CL, and ML. The following soil types are considered unsuitable: Pt, OH, OL, CH, and MH.

6.5.3 Placement and Compaction Requirements

Structural fill placement and compaction shall meet the requirements of Section 6.5.2. Engineered fill should be placed in lifts of maximum eight inches loose measurement. The soil should be compacted by mechanical means such as steel drum, sheepsfoot, tamping, or rubber-tired rollers. Compaction of clays is best accomplished with a sheepsfoot or tamping roller. Periodically rolling with heavily loaded, rubber-tired equipment may be desirable to seal the surface of the compacted fill, thus reducing the potential for absorption of surface water following a rain. This sealing operation is particularly important at the end of the work day and at the end of the week.

Within confined areas or foundation excavations, we recommend the use of manually operated, internal combustion activated compactors (“whacker packers” or sled tamps). The compactors should have sufficient weight and striking power to produce the same degree of compaction that is obtained on the other portions of the fill by the rolling equipment as specified. Where hand operated equipment is used, the soils should be placed in lifts of maximum four inches loose measurement.

Materials placed at the site should be compacted to minimum dry densities corresponding to 92% of maximum dry density, and at moisture contents within +/- 2% of optimum moisture content, as obtained by Modified Proctor, ASTM D1557. The top 2.0 feet of all areas to receive pavement or structures should be compacted to 95% of its modified proctor value.

6.5.4 Grading and Drainage

Surface water, perched water, or groundwater should not be allowed to collect within structure and pavement areas during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of collected rainwater, groundwater, or surface runoff with pumping from filtered sumps. Typically, groundwater should be lowered and maintained at depth of at least 2 feet below shallow foundation bearing levels and trench excavation bottoms during construction. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath floor slabs. Site grading activities, where possible, should be scheduled for the drier, hotter months of the year to reduce the potential for construction problems associated with wet soils, groundwater, and wet weather.

Notes for Drawings: The following note should be added to an appropriate civil/site plate and to an appropriate structural foundation plate of the contract drawings:

“Drainage and Dewatering: All excavations shall be performed so that the site and the area immediately surrounding the site which affects construction operations will be continually and effectively drained. The Contractor shall provide drainage and dewatering as required to ensure that all footing and grade beam excavations are accomplished with the subgrade soils remaining dry and firm until after footings are placed and backfilled. Removal of surface water, groundwater, and any perched-water conditions, which might be encountered during excavations shall be accomplished by approved means. Refer to Specification 31 00 00 EARTHWORK for additional requirements.”

6.5.5 Construction Considerations

The foundation bearing area should be level or suitably benched. Loose soil, debris, and excess surface water should be removed from the bearing surface prior to concrete placement. The strength and performance of foundation subgrade soils can be adversely impacted by excessive exposure.

Foundation subgrade soils exposed in open excavations should be protected from freezing weather, severe drying, and water accumulation. Any soils disturbed by exposure should be removed prior to foundation concrete placement. If the excavations must remain open overnight, the bearing soils should be protected with black plastic or similar opaque impermeable material to reduce moisture loss and shrinkage of the soils. If the excavations must remain open for an extended period, a "lean" concrete mud-mat with a minimum thickness of 3 inches should be placed over the bearing soils. Excavation of disturbed soil may be required if these protective measures are not implemented.

6.6 Floor Slab-on-Grade

Preparation of the natural soil, prior to placement of structural fill, should be consistent with the earthwork recommendations presented in this report.

6.6.1 Design Recommendations

General Slab Design: The floor slab subgrade for the main building is recommended to consist of a geogrid-reinforced granular fill (load transfer platform). Subgrades for the planned drying tower are anticipated to consist of new structural fill place over native soils. Concrete floor slabs should be placed in accordance with the specification Section 31 00 00, EARTHWORK.

Capillary Water Barrier/Vapor Barrier: It is recommended that concrete slabs-on-grade in enclosed habitable areas be underlain by a minimum of 4 inches of open graded, washed pea gravel or stone, often termed “capillary water barrier,” to reduce the capillary rise of the groundwater. Nos. 57, 67, 78, or 89 stone should be used. Drawings should be consistently labeled with the term “capillary water barrier,” since this is the term utilized in Section EARTHWORK of the Specifications. A vapor barrier consisting of lapped polyethylene sheeting having a minimum thickness of 10 mils should be provided beneath building floor slabs to reduce the potential for slab dampness from soil moisture. The vapor barrier material may be omitted under slabs-on-grade in unenclosed areas; however, all slabs shall be provided with a capillary water barrier. Concrete slabs should be jointed around columns and along supported walls to minimize cracking due to possible differential movement.

Modulus of Subgrade Reaction: Provided that the upper 12 inches of suitable subgrade will be prepared as recommended in this report, a vertical modulus of subgrade reaction (k) of **125 pci** (based on a 12-foot square plate) should be used for the design of the slab-on-grade.

Design for Differential Movements: Floor slabs should be structurally independent of building foundations to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.

Line Loads: The design of thickened slabs on grade to support line loads (such as partitions and light wall loads) should be in accordance with UFC-3-301-01, Structural Engineering.

6.6.2 Construction Considerations

Construction activities and exposure to the environment often cause deterioration of the prepared slab-on-grade subgrade. Therefore, the slab subgrade soil shall be inspected and evaluated immediately prior to floor slab construction. The evaluation might include a combination of visual observations, proof rolling, hand rod probing, and field density tests to verify that the subgrade has been properly prepared.

If unstable soil is revealed, the affected soil should be removed to firm bearing and replaced to design subgrade with suitable structural fill soil placed and compacted as recommended or replaced with additional vapor retarder material.

6.7 Seismic Design Parameters

The seismic site classification for the proposed project was evaluated in accordance with Chapter 20 of ASCE 7-16. Based on the site location and exploration results, we recommend the following parameters be used in design:

Table 6-2. Seismic Site Classification and Ground Motion Parameters

Seismic site classification	F^1
Average shear wave velocity, $V_{s,30}$ (ft/s)	963 fps
MCE_R spectral response acceleration parameter (for 0.2s period)	$S_S = 0.287$
MCE_R spectral response acceleration parameter (for 1.0s period)	$S_1 = 0.107$
MCE_R spectral response acceleration parameter (0.2s period) adjusted for site class effects	$S_{MS} = 0.451^2$
MCE_R spectral response acceleration parameter (1.0s period) adjusted for site class effects	$S_{M1} = 0.256^2$
Design spectral response acceleration (0.2s period)	$S_{DS} = 0.301g$
Design spectral response acceleration (1.0s period)	$S_{D1} = 0.171g$
Site amplification factor at 0.2s	$F_a = 1.57$
Site amplification factor at 1.0s	$F_v = 2.385$

1. Per ASCE 7-16, any profile containing soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils.
2. For structures with fundamental periods of vibration less than 0.5 seconds, Section 20.3.1 of ASCE 7-16 allows values of F_a and F_v to be determined assuming that liquefaction does not occur (i.e., Site Class D). For the drying tower, a Site Class D is permitted where liquefiable soils are mitigated as outlined in this report.

6.8 Pavement Design Criteria

New fill placed on approved subgrades will be required in pavement areas. Provided unsatisfactory subgrade soils that are encountered are removed and replaced with satisfactory soils, the following subgrade values for satisfactory soils and other listed parameters may be used for the design of the pavements:

- (1) Flexible (Asphaltic Concrete) Pavement:
Compacted subgrade, use CBR of 8.
- (2) Rigid (Portland Cement Concrete) Pavement:
 - (a) Use a corrected modulus of subgrade reaction, K of 150 psi per inch with at least 4 inches of compacted aggregate base course.

- (b) The concrete should have a minimum design 28-day compressive strength of at least 4,000 pounds per square inch with a mix design that has been proven to produce concrete with a flexural strength of at least 650 psi.

7. GEOTECHNICAL AND CONSTRUCTION QUALITY CONTROLS

Sampling and Classification: Prior to initiating structural fill placement and/or compaction operations, it is recommended that representative samples of the soils which will be used as structural fill, be obtained, and tested to determine their classification and compaction characteristics. The samples should be carefully selected to represent the full range of soil types to be used. The moisture content, maximum dry density, optimum moisture content, grain-size, and plasticity characteristics should be determined. These tests are required to determine if the fill and subgrade soils are acceptable and for compaction quality control of the subgrades and structural fill. Tests for the above soil properties should be in accordance with the following:

• Moisture Content	ASTM D2216
• Maximum Dry Density and Optimum Moisture	ASTM D1557
• Grain-Size (Wash No. 200, less hydrometer)	ASTM D6913 and D1140
• Plasticity	ASTM D4318

Laboratory and field density testing should be performed by a commercial testing laboratory that has been validated by the Engineer Research and Development Center Materials Testing Center (MTC) under the Corps of Engineers laboratory inspection and validation program.

Testing Frequency: In-place density tests should be performed in accordance with the sand cone method prescribed in ASTM D1556 or nuclear density gauge detailed in ASTM D6938. It is recommended that at least one density test be performed for each 500 square feet of compacted native soil subgrade and in each lift of compacted structural fill for the building and pavements. In addition, a density test should be performed for each 100 linear feet of backfill placed per foot of depth in trenches for utilities.

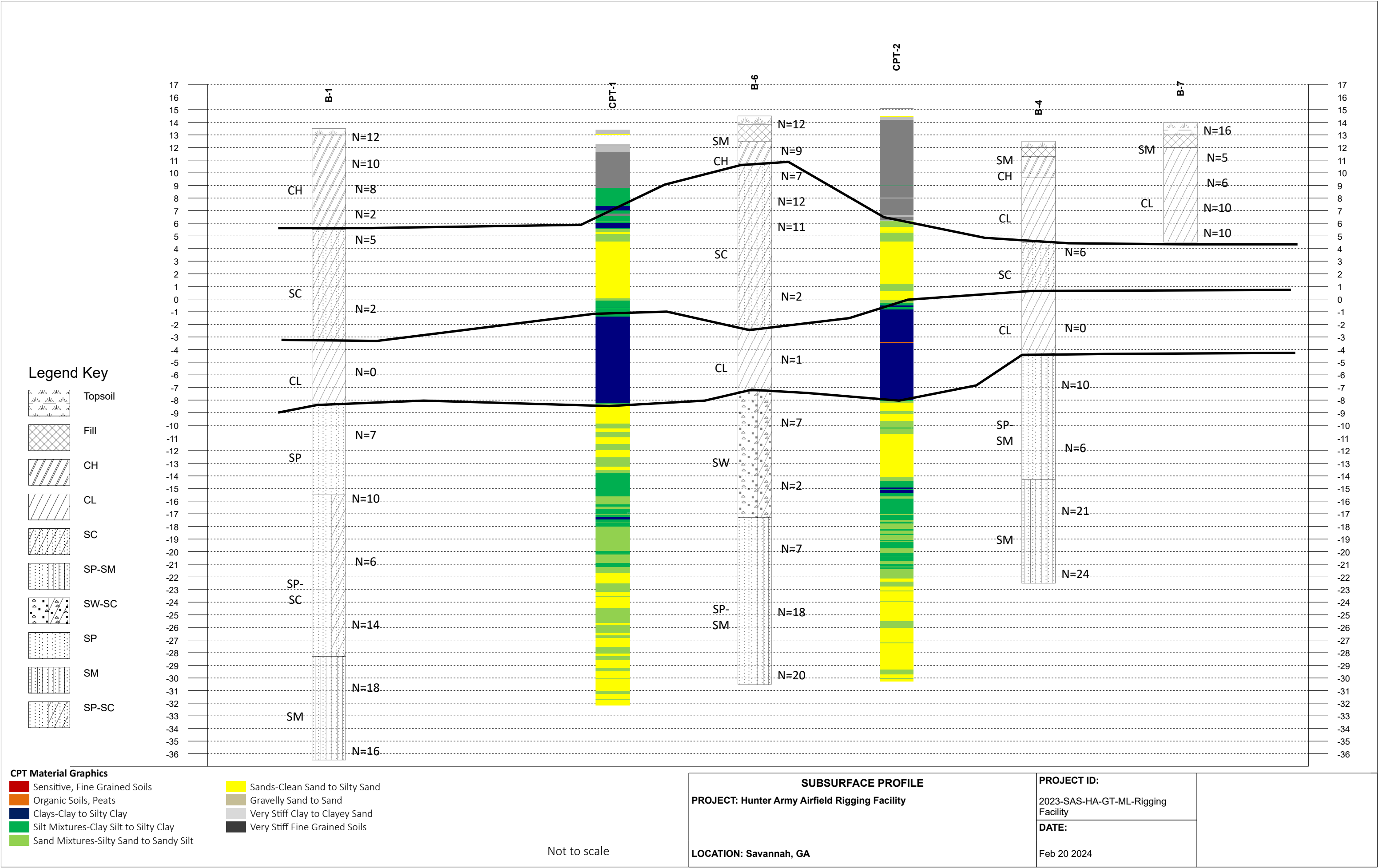
Retesting: Areas that do not meet the required compaction criteria should be reworked and retested. If the moisture content of the soil is within the recommended range, additional compaction may be all that is necessary to increase the density. If the moisture content is not within the recommended range, the moisture content should be adjusted to within the range and the area recompacted.

7.1 Presentation of Subsurface Exploration Data

Subsurface exploration locations are shown on the exploration location plan located in the Appendix and can also be provided in electronic format. The exploration locations should be referenced and shown on the appropriate site grading and drainage plates of the contract drawings. SPT/CPT location symbols (circle with the right half-filled in) should also be placed in the civil legend. Soil test boring logs are also shown in the Appendix. Drawings containing the soil boring logs will be provided as well. The drawings should be directly inserted into the project drawings, and the plate titles should be included in the index.

APPENDIX A

FIELD EXPORATION



Boring Designation										B-1					
DRILLING LOG			DIVISION South Atlantic			INSTALLATION Hunter Army Airfield			Sheet 1 of 2						
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA						10. COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet				VERTICAL NAVD88					
2. HOLE NUMBER B-1						3. DRILLING AGENCY Corps of Engineers - CESAS			11. DATE BORING Jul 11 2023		12. HAMMER TYPE Automatic, 30" drop				
4. NAME OF DRILLER Steven Widincamp						13. SIZE AND TYPE OF BIT Mud rotary				EFFICIENCY (%) 72.0					
5. EQUIPMENT Diedrich D-70						14. ELEVATION SURFACE 13.5'									
6. DIRECTION OF BORING Vertical						DEG FROM VERTICAL			BEARING						
7. THICKNESS OF OVERBURDEN 74.5'						15. ELEVATION GROUND WATER - See Remarks									
8. DEPTH DRILLED INTO ROCK						16. TOTAL NUMBER CORE BOXES									
9. TOTAL DEPTH OF BORING 74.5'						17. SIGNATURE AND TITLE OF INSPECTOR Colby Brown, Field Geologist									
ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS						
13.00	0.50	2	12	14		Topsoil	93	S-1	Groundwater levels could not be accurately determined due to the introduction of drilling fluids for borehole stabilization. Sample S-2 % Fines = 65 LL = 61 PI = 41 MC = 19%						
		4				FAT CLAY (CH) fine sand; light brownish gray and light yellowish brown, moist, stiff to soft, some fine to medium sand									
		8					67	S-2							
		2	10	12											
		4					67	S-3							
		6													
		4	8	10											
		3													
		5													
		2	2	2			20	S-4							
5.50	8.00	1				CLAYEY SAND (SC) fine sand; gray, wet, loose to very loose, some clay	40	S-5	Sample S-6 % Fines = 38 LL = 38 PI = 20						
		3													
		2													
		3	5	6											
		1													
		1	2	2			87	S-6							
		1													
-3.30	16.80						LEAN CLAY (CL) dark gray and reddish brown, wet, very soft, some fine sand	100				S-7	Weight of Hammer (WOH) - A weight of hammer event occurs during standard penetration testing when the hammer and drill string (drilling rod and split spoon sampler) are allowed to rest on the bottom of the borehole and they sink under their own weight. Sample S-7 % Fines = 50 LL = 43 PI = 24 MC = 49		
		0													
		0													
		0	W	0											
			O												
			H												
-8.30	21.80						POORLY GRADED SAND (SP) fine to coarse sand; dark gray, wet, loose, trace fine gravel, trace silt	87	S-8	Sample S-8 % Fines = 4 LL = NP					
		1													
		3													
		4	7	8											
		6													
		6													
		4	10	12			93	S-9							
-15.50	29.00						POORLY GRADED SAND WITH CLAY (SP-SC) fine to coarse sand; dark gray, wet, medium dense to loose, few clay, trace fine gravel						Sample S-10 % Fines = 12		
		1	6	7		100	S-10								
		2													
		4													

(continued on next page)

USACE FORM 1836 Boring Designation B-1 Sheet 1 of 2

Boring Designation					B-1				
DRILLING LOG (Cont Sheet)					INSTALLATION Hunter Army Airfield		Sheet 2 of 2		
PROJECT Hunter Army Airfield Rigging Facility Savannah, GA					COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet			VERTICAL NAVD88	
					LOCATION COORDINATES N: 731192.51 E: 964600.99		LOCATION METHOD:		
ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS
-23.30	36.80					POORLY GRADED SAND WITH CLAY (SP-SC) fine to coarse sand; dark gray, wet, medium dense to loose, few clay, trace fine gravel			
		3 4 10	14	17		SILTY SAND (SM) fine to medium sand; reddish brown, wet, medium dense, little silt	100	S-11	
		3 6 12	18	22			100	S-12	
-36.50	50.00	4 7 9	16	19			87	S-13	Sample S-13 % Fines = 13 LL = NP MC = 34%
		20 37 52	89	100+		SILTY SAND (SM) fine sand; dark brownish gray to greenish gray, moist, very dense to dense, some silt, few shell fragments, (marl)	100	S-14	
		20 49 50	50/ 2"	100+			100	S-15	
-61.00	74.50	5 10 16	26	31			100	S-16	
						Borehole terminated at 74.5-ft bgs			

Boring Designation					B-1A			
DRILLING LOG		DIVISION South Atlantic		INSTALLATION Hunter Army Airfield		Sheet 1 of 1		
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA				10. COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet		VERTICAL NAVD88		
2. HOLE NUMBER B-1A				3. DRILLING AGENCY Corps of Engineers - CESAS		LOCATION COORDINATES N: 731190.72 E: 964603.80		
4. NAME OF DRILLER Steven Widincamp				11. DATE BORING Jul 14 2023		LOCATION METHOD: COMPLETED Jul 14 2023		
5. EQUIPMENT Diedrich D-70				12. HAMMER TYPE Automatic, 30" drop		EFFICIENCY (%) 72.0		
6. DIRECTION OF BORING Vertical		DEG FROM VERTICAL		BEARING		14. ELEVATION SURFACE 13.5'		
7. THICKNESS OF OVERBURDEN 20.0'				15. ELEVATION GROUND WATER - See Remarks				
8. DEPTH DRILLED INTO ROCK				16. TOTAL NUMBER CORE BOXES				
9. TOTAL DEPTH OF BORING 20.0'				17. SIGNATURE AND TITLE OF INSPECTOR Colby Brown, Field Geologist				
ELEV	DEPTH	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)		% REC	Samp No.	REMARKS	
9.50	4.00		Boring B-1A is a companion boring to B-1 and was drilled to collect undisturbed samples. 2-ft Shelby tube samples were obtained at depths of 4 and 18 feet bgs, respectively.				Groundwater levels could not be accurately determined due to the introduction of drilling fluids for borehole stabilization.	
7.50	6.00		FAT CLAY (CH) light gray and reddish brown, moist, little fine to medium sand			ST-1		Sample ST-1 % Fines = 79 LL = 96 PI = 68 MC = 29%
			6.0 ft to 18.0 ft bgs - un-sampled.					
-4.50	18.00		CLAYEY SAND (SC) fine sand; light gray and gray, wet, some clay			ST-2	Sample ST-2 % Fines = 48 LL = 51 PI = 32 MC = 50%	
			Borehole terminated at 20-ft bgs					

B-2

Sheet 1 of 1

NAVD88

LOCATION METHOD:

COMPLETED
Jul 12 2023

EFFICIENCY (%)
72.0

13. SIZE AND TYPE OF BIT
Mud rotary

14. ELEVATION SURFACE	12.5'

15. ELEVATION GROUND WATER	- See Remarks

16. TOTAL NUMBER CORE BOXES	

17. SIGNATURE AND TITLE OF INSPECTOR

Colby Brown, Field Geologist

Sheet 1 of 1

Boring Designation										B-3			
DRILLING LOG				DIVISION South Atlantic				INSTALLATION Hunter Army Airfield				Sheet 1 of 2	
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA				10. COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet LOCATION COORDINATES N: 731070.76 E: 964693.87				VERTICAL NAVD88 LOCATION METHOD:					
2. HOLE NUMBER B-3		3. DRILLING AGENCY Corps of Engineers - CESAS				11. DATE BORING STARTED Jul 14 2023		COMPLETED Jul 14 2023					
4. NAME OF DRILLER Steven Widincamp				12. HAMMER TYPE Automatic, 30" drop				EFFICIENCY (%) 72.0					
5. EQUIPMENT Diedrich D-70				13. SIZE AND TYPE OF BIT Mud rotary									
6. DIRECTION OF BORING Vertical		DEG FROM VERTICAL		BEARING		14. ELEVATION SURFACE 17.0'		15. ELEVATION GROUND WATER - See Remarks					
7. THICKNESS OF OVERBURDEN 45.0'				16. TOTAL NUMBER CORE BOXES									
8. DEPTH DRILLED INTO ROCK				17. SIGNATURE AND TITLE OF INSPECTOR									
9. TOTAL DEPTH OF BORING 45.0'				Colby Brown, Field Geologist									
ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS				
16.80	0.20	1	7	8		Topsoil	87	S-1	Groundwater levels could not be accurately determined due to the introduction of drilling fluids for borehole stabilization. Sample S-2 % Fines = 29 LL = 29 PI = 14 MC = 13% PP = 1.00 tsf PP = 1.75 tsf PP = 2.5 tsf				
		2											
		5											
		3											
		11	19	23		CLAYEY SAND (SC) fine sand; light brownish gray to light brown, moist, some clay, FILL	67	S-2					
		8											
12.50	4.50	3											
		3											
		4	7	8		LEAN CLAY (CL) light brownish gray, moist to wet, stiff, little fine sand	87	S-3					
		3											
		4											
		4											
		3	8	10			80	S-4					
		4											
		4											
		3											
		3	7	8			80	S-5					
		3											
		4											
		4											
3.00	14.00	1	7	8		POORLY GRADED SAND WITH SILT (SP-SM) fine sand; light brown and gray, wet, loose, few silt	53	S-6					
		2											
		5											
		1											
		2	6	7			67	S-7	Sample S-7 % Fines = 12				
		4											
		1											
		5											
		4	5	6			100	S-8					
		1											
		1											
		1											
-9.80	26.80	0	1	1		CLAYEY SAND (SC) fine to medium sand; brown to dark gray, wet, very loose, little clay	100	S-9	Sample S-9 % Fines = 26 LL = 34 PI = 15				
		0											
		0											
		1											
-17.00	34.00	3	7	8		POORLY GRADED SAND (SP-SM) fine sand; dark gray, wet, loose to medium dense, few silt	93	S-10					
		3											
		4											
		4											

(continued on next page)

USACE FORM 1836

Boring Designation

B-3

Sheet 1 of 2

B-3

INSTALLATION

Hunter Army Airfield

Sheet 2 of 2

COORDINATE SYSTEM

VERTICAL

NAD 1983 StatePlane Georgia East FIPS 1001 Feet

NAVD88

E: 964693.87

LOCATION METHOD:

ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS
-28.00	45.00	3 3 6	9	11		POORLY GRADED SAND (SP-SM) fine sand; dark gray, wet, loose to medium dense, few silt	100	S-11	
		6 9 14	23	28			93	S-12	
						Borehole terminated at 45-ft bgs			

Boring Designation										B-4		
DRILLING LOG			DIVISION South Atlantic				INSTALLATION Hunter Army Airfield				Sheet 1 of 1	
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA						10. COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet				VERTICAL NAVD88		
2. HOLE NUMBER B-4			3. DRILLING AGENCY Corps of Engineers - CESAS			11. DATE BORING Jul 13 2023		STARTED Jul 13 2023		COMPLETED Jul 13 2023		
4. NAME OF DRILLER Steven Widincamp						12. HAMMER TYPE Automatic, 30" drop				EFFICIENCY (%) 72.0		
5. EQUIPMENT Diedrich D-70						13. SIZE AND TYPE OF BIT Mud rotary						
6. DIRECTION OF BORING Vertical		DEG FROM VERTICAL		BEARING		14. ELEVATION SURFACE 12.5'						
7. THICKNESS OF OVERBURDEN 35.0'						15. ELEVATION GROUND WATER 5.7' - during hand auger						
8. DEPTH DRILLED INTO ROCK						16. TOTAL NUMBER CORE BOXES						
9. TOTAL DEPTH OF BORING 35.0'						17. SIGNATURE AND TITLE OF INSPECTOR Colby Brown, Field Geologist						
ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)		% REC	Samp No.	REMARKS		
12.00	0.50					Topsoil				Advanced boring by hand auger from 0 ft to 8 ft below ground surface because an untraceable sanitary sewer is in the vicinity of the boring location.		
11.30	1.20					SILTY SAND (SM) fine sand; light brown, moist, little silt, FILL			S-1			
						FAT CLAY (CH) light brownish gray, moist, little fine sand						
9.60	2.90					LEAN CLAY (CL) light brownish gray and yellowish brown, moist to wet, little fine sand				S-2	Weight of Hammer (WOH) - A weight of hammer event occurs during standard penetration testing when the hammer and drill string (drilling rod and split spoon sampler) are allowed to rest on the bottom of the borehole and they sink under their own weight.	
									S-3			
									S-4			
4.50	8.00											
		4 3 3	6	7		CLAYEY SAND (SC) fine to medium sand; gray, wet, loose, some clay		87	S-5			
0.70	11.80					LEAN CLAY (CL) gray, wet, very soft, some fine sand						
		0 0 0	W O H	0				100	S-6			
-4.30	16.80					POORLY GRADED SAND WITH SILT (SP-SM) fine to coarse sand; dark gray, wet, medium dense to loose, few silt						
		0 5 5		10	12			93	S-7			
		2 3 3	6	7				53	S-8			
-14.30	26.80					SILTY SAND (SM) fine sand; dark gray, wet, medium dense, little silt						
		4 7 14	21	25				87	S-9			
		6 8 16	24	29				87	S-10			
-22.50	35.00					Borehole terminated at 35-ft bgs						

USACE FORM 1836

Boring Designation

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Sheet 1 of 1

Boring Designation										B-6					
DRILLING LOG				DIVISION South Atlantic				INSTALLATION Hunter Army Airfield				Sheet 1 of 2			
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA				10. COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet				VERTICAL NAVD88							
								LOCATION COORDINATES N: 731058.32 E: 964528.13 LOCATION METHOD:							
2. HOLE NUMBER B-6		3. DRILLING AGENCY Corps of Engineers - CESAS				11. DATE BORING STARTED Jul 07 2023		COMPLETED Jul 07 2023							
4. NAME OF DRILLER Caleb Graffagnino				12. HAMMER TYPE Automatic, 30" drop				EFFICIENCY (%) 89.4							
5. EQUIPMENT SAS-CME 850XR				13. SIZE AND TYPE OF BIT 4.25" HSA											
6. DIRECTION OF BORING Vertical		DEG FROM VERTICAL		BEARING		14. ELEVATION SURFACE 14.5'									
						15. ELEVATION GROUND WATER 3.0' - In auger									
7. THICKNESS OF OVERBURDEN 45.0'				16. TOTAL NUMBER CORE BOXES											
8. DEPTH DRILLED INTO ROCK				17. SIGNATURE AND TITLE OF INSPECTOR											
9. TOTAL DEPTH OF BORING 45.0'				Colby Brown, Field Geologist											
ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS						
13.80	0.70	2	12	18		Topsoil	93	S-1	Sample S-3 % Fines = 43 LL = 39 PI = 25 MC = 19.0%	10					
12.50	2.00	5				SILTY SAND (SM) light brownish gray, dry, little silt, FILL									
		7													
10.70	3.80	4	9	13		FAT CLAY (CH) light brownish gray and light yellowish brown, moist, stiff, some fine to medium sand	80	S-2							
		5													
		1	7	10		CLAYEY SAND (SC) fine sand; grayish brown to gray, moist to wet, medium dense to very loose, some clay	87	S-3			Sample S-5 % Fines = 26 LL = 30 PI = 9 MC = 21%	5			
		3													
		6	12	18		87	S-4								
		6													
		2	11	16		93	S-5								
		5													
				6											
				1	2	3		LEAN CLAY (CL) dark gray and reddish brown, wet, very soft, some fine sand	73	S-6			Weight of Hammer (WOH) - A weight of hammer event occurs during standard penetration testing when the hammer and drill string (drilling rod and split spoon sampler) are allowed to rest on the bottom of the borehole and they sink under their own weight.	-5	
				1											
		1													
-2.30	16.80														
		0	1	1			100	S-7							
		0													
		1													
-7.30	21.80														
		0	7	10		WELL GRADED SAND (SW) fine to coarse sand; grayish brown and dark gray, wet, loose to very loose, trace clay	100	S-8	Sample S-8 % Fines = 4.8 LL = 32 PI = 14	-10					
		1													
		6													
		0	2	3			100	S-9		-15					
		1													
		1													
-17.30	31.80														
		2	7	10		POORLY GRADED SAND WITH SILT (SP-SM) fine sand; grayish brown and dark gray, wet, medium dense to dense, few silt	100	S-10		-20					
		3													
		4													
(continued on next page)															
USACE FORM 1836				Boring Designation				B-6		Sheet 1 of 2					

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INSTALLATION

Hunter Army Airfield

Sheet 2 of 2

COORDINATE SYSTEM

VERTICAL

NAD 1983 StatePlane Georgia East FIPS 1001 Feet

NAVD88

E: 964528.13

LOCATION METHOD:

ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS
-30.50	45.00	4 7 11	18	27		POORLY GRADED SAND WITH SILT (SP-SM) fine sand; grayish brown and dark gray, wet, medium dense to dense, few silt	93	S-11	Sample S-11 % Fines = 12 LL = NP
		5 8 12	20	30			100	S-12	
						Borehole terminated at 45-ft bgs			

B-7

DRILLING LOG		DIVISION South Atlantic		INSTALLATION Hunter Army Airfield		Sheet 1 of 1		
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA				10. COORDINATE SYSTEM			VERTICAL	
				NAD 1983 StatePlane Georgia East FIPS 1001 Feet			NAVD88	
2. HOLE NUMBER B-7				3. DRILLING AGENCY Corps of Engineers - CESAS		LOCATION COORDINATES		LOCATION METHOD:
						N: 730722.38	E: 964237.02	
				11. DATE BORING		STARTED Jul 07 2023	COMPLETED Jul 07 2023	
4. NAME OF DRILLER Caleb Graffagnino				12. HAMMER TYPE Automatic, 30" drop				EFFICIENCY (%) 89.4
5. EQUIPMENT SAS-CME 850XR				13. SIZE AND TYPE OF BIT 4.25" HSA				
6. DIRECTION OF BORING		DEG FROM VERTICAL		BEARING		14. ELEVATION SURFACE		14.0'
Vertical						15. ELEVATION GROUND WATER		- Not Encountered
7. THICKNESS OF OVERBURDEN				9.5'		16. TOTAL NUMBER CORE BOXES		
8. DEPTH DRILLED INTO ROCK						17. SIGNATURE AND TITLE OF INSPECTOR		
9. TOTAL DEPTH OF BORING				9.5'		Colby Brown, Field Geologist		

ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS	
13.00	1.00	2 7	16	24		Topsoil	87	S-1	Sample S-2 % Fines = 50 LL = 45 PI = 29 MC = 25%	
12.00	2.00	9				SILTY SAND (SM) fine sand; brown, moist, little silt, FILL				
		2 2 3	5	7		LEAN CLAY (CL) light yellowish brown and gray, moist, medium stiff to stiff, some fine sand	80	S-2		
		2 2 4	6	9			87	S-3		
		4 4 6	10	15			93	S-6		
		3 5 5	10	15			100	S-8		
4.50	9.50	5								
Borehole terminated at 9.5-ft bgs										

Boring Designation										B-8			
DRILLING LOG				DIVISION South Atlantic				INSTALLATION Hunter Army Airfield				Sheet 1 of 1	
1. PROJECT Hunter Army Airfield Rigging Facility Savannah, GA				10. COORDINATE SYSTEM NAD 1983 StatePlane Georgia East FIPS 1001 Feet LOCATION COORDINATES N: 730968.64 E: 964429.75				VERTICAL NAVD88 LOCATION METHOD:					
2. HOLE NUMBER B-8		3. DRILLING AGENCY Corps of Engineers - CESAS				11. DATE BORING STARTED Jul 10 2023		COMPLETED Jul 11 2023					
4. NAME OF DRILLER Caleb Graffagnino				12. HAMMER TYPE Automatic, 30" drop				EFFICIENCY (%) 72.0					
5. EQUIPMENT SAS-CME 850XR				13. SIZE AND TYPE OF BIT Mud rotary									
6. DIRECTION OF BORING Vertical		DEG FROM VERTICAL		BEARING		14. ELEVATION SURFACE 14.5'		15. ELEVATION GROUND WATER - See Remarks					
7. THICKNESS OF OVERBURDEN 35.0'				16. TOTAL NUMBER CORE BOXES									
8. DEPTH DRILLED INTO ROCK				17. SIGNATURE AND TITLE OF INSPECTOR									
9. TOTAL DEPTH OF BORING 35.0'				Colby Brown, Field Geologist									
ELEV	DEPTH	BLOWS/ 0.5ft	N	N60	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	REMARKS				
12.30	-2.20	1	5	6		Topsoil	33	S-1	Groundwater levels could not be accurately determined due to the introduction of drilling fluids for borehole stabilization.				
		2											
		3											
8.30	-6.20	2	10	12		FAT CLAY (CH) moist, stiff, some fine sand	93	S-2					
		4											
		6											
		3											
		4											
		6											
2.70	-11.80	2	11	13		CLAYEY SAND (SC) fine sand; moist to wet, medium dense, some clay	87	S-4		Sample S-4 % Fines = 37 LL = 36 PI = 21 MC = 21%			
		4											
		7											
		3											
		5											
		6											
-7.30	-21.80	1	3	4		POORLY GRADED SAND WITH SILT (SP-SM) fine sand; wet, loose, few silt	87	S-6					
		1											
		2											
		5											
		4											
		2											
-14.50	-29.00	0	4	5		CLAYEY SAND (SC) fine to medium sand; wet, loose, some clay	67	S-8	Weight of Hammer (WOH) - A weight of hammer event occurs during standard penetration testing when the hammer and drill string (drilling rod and split spoon sampler) are allowed to rest on the bottom of the borehole and they sink under their own weight.				
		1											
		3											
		7											
		5											
		8											
-20.50	-35.00	5	18	22		POORLY GRADED SAND WITH SILT (SP-SM) fine to medium sand; wet, medium dense, few silt	80	S-9		Sample S-8 % Fines = 17 LL = 32 PI = 16 Sample S-10 % Fines = 12 LL = 50 PI = 13			
		7											
		11											
		5											
		7											
		11											
Borehole terminated at 35-ft bgs													

USACE FORM 1836

Boring Designation

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Sheet 1 of 1



Hunter Army Airfield
HAA (Savannah, GA)
Project No: Rigging Facility

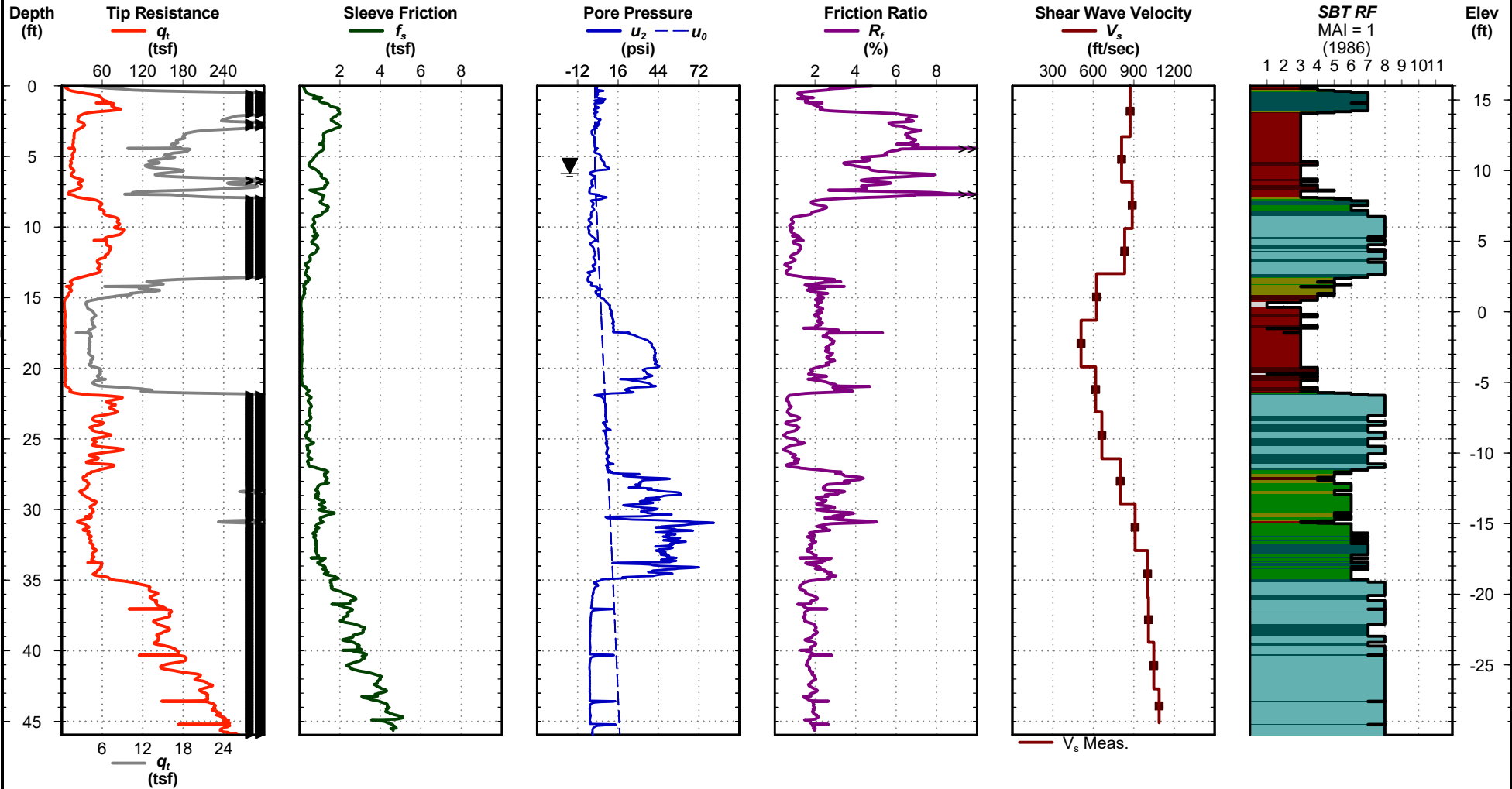
Cone Penetration Test

CPT-1

Date: Sep. 15, 2023
Operator: Tyler Castellaw
Drilling Agency: USACE, Savannah District

Latitude: 32° 0' 23.3136"
Longitude: -81° 10' 18.1524"
Probe ID/Net Area Ratio: DSG1071 / 0.8

Elevation: 16.0
Water Depth: 6.2
Total Depth: 46.0 ft





Hunter Army Airfield
HAA (Savannah, GA)
Project No: Rigging Facility

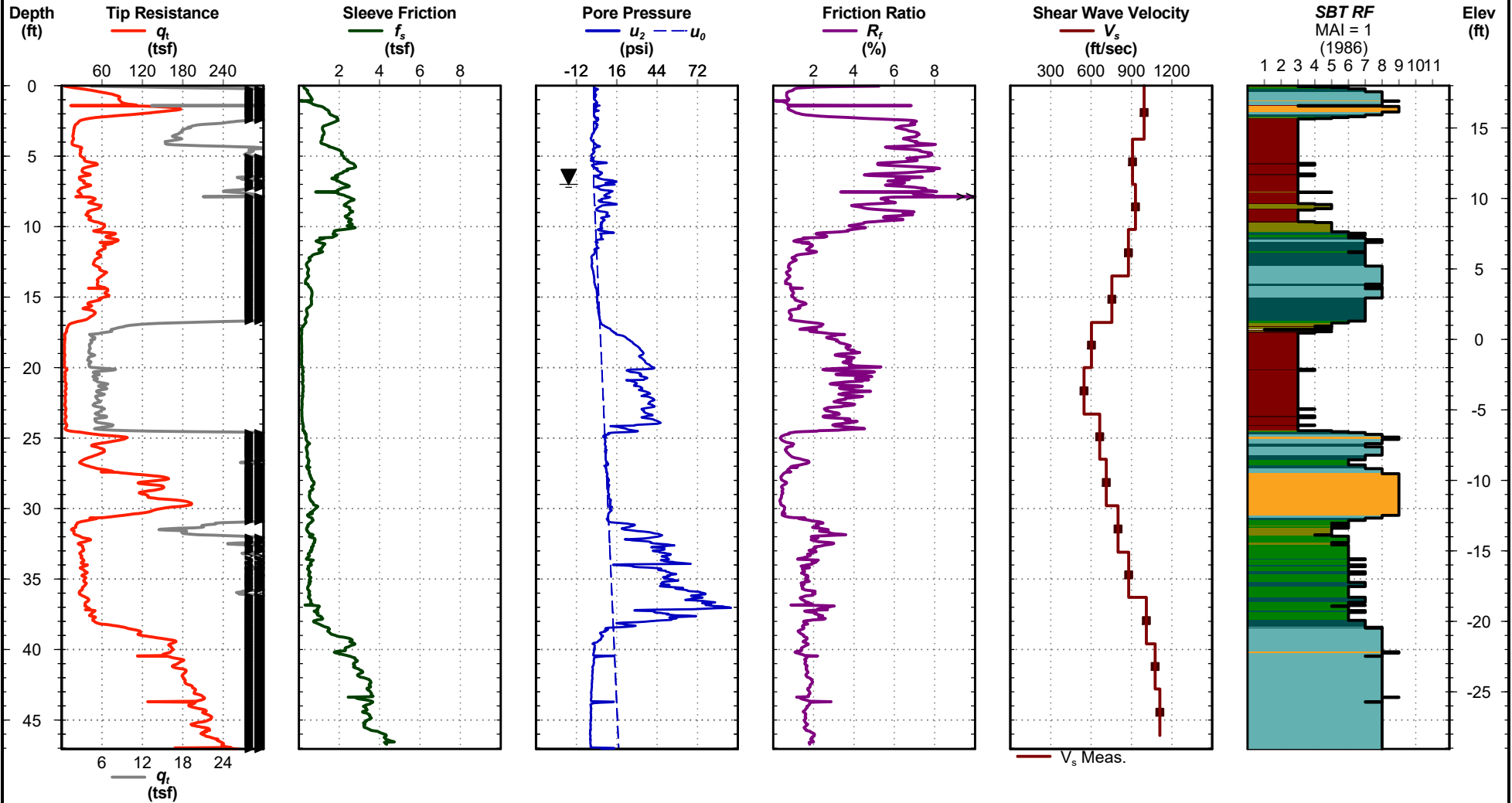
Cone Penetration Test

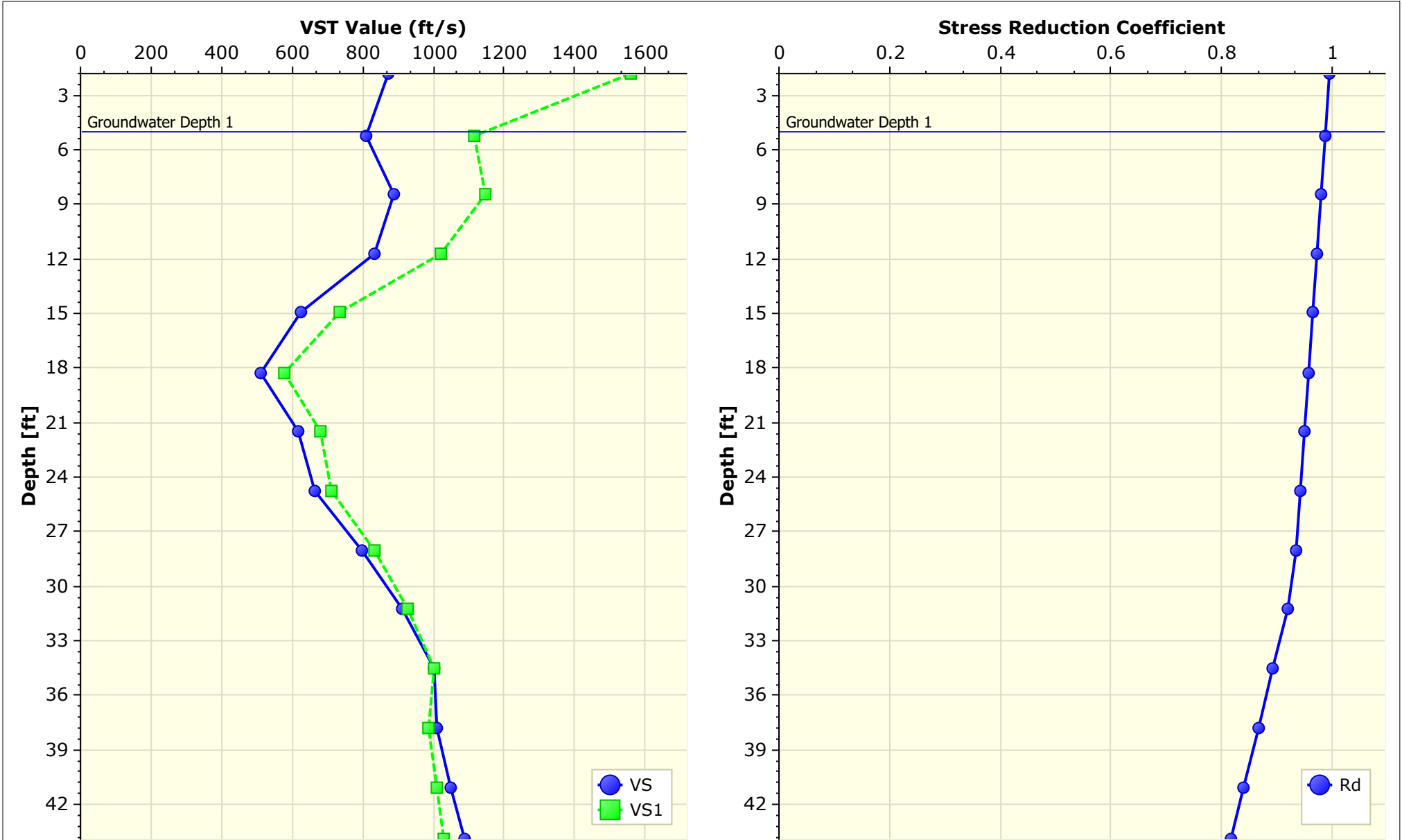
CPT-2

Date: Sep. 15, 2023
Operator: Tyler Castellaw
Drilling Agency: USACE, Savannah District

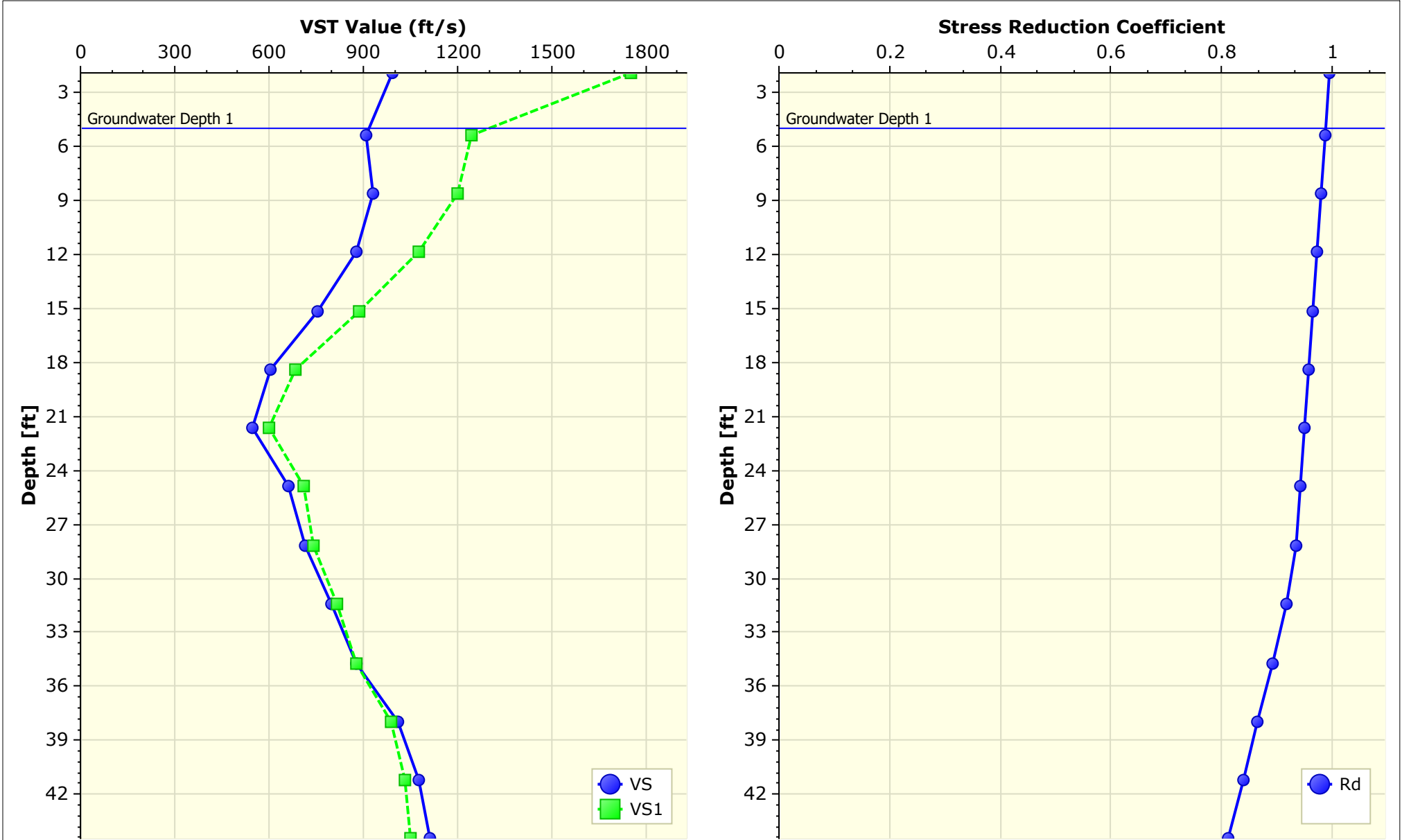
Latitude: 32° 0' 21.69"
Longitude: -81° 10' 18.2676"
Probe ID/Net Area Ratio: DSG1071 / 0.8

Elevation: 18.0
Water Depth: 7
Total Depth: 47.1 ft





rocscience	Project	Hunter AAF, Consolidated Parachute Rigging Facility	
	Analysis Description	SCPT-1: Shear Wave Velocity Measurements	
	Drawn By	N.Bryan	Company USACE Savannah District
	Date	2/26/2024, 2:10:50 PM	File Name SCPT-1



	Project	Hunter AAF, Consolidated Parachute Rigging Facility	
	Analysis Description	SCPT-2: Shear Wave Velocity Measurements	
	Drawn By	N.Bryan	Company CESAS
	Date	2/26/2024, 2:10:50 PM	File Name SCPT-2

Rigging Facility
P.N. 81905
Hunter AAF, GA
Engineer:

BAS Date: 12/21/2023

Soil percolation tests were performed in accordance with DM 110-1-1, Jul 83, chapter 20.

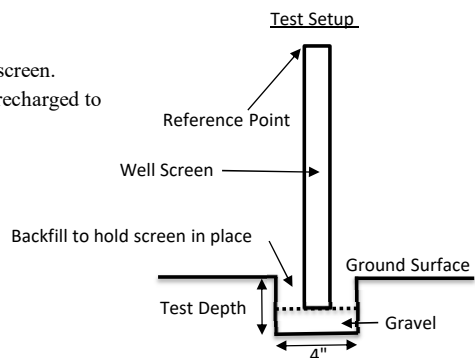
Weather Conditions: Sunny 40's to 60's F

Various lengths of slotted pvc pipe screens were placed in each hole to minimize difficulties associated with hole cave-in.

Water levels were measured by a water level indicator with a reference point on the slotted pipe screen.

A minimum 6" water column above gravel was used as the initial height of water, subsequently recharged to this level after each reading as necessary. All times were noted by a watch with a second hand.

The Michigan method is used to estimate infiltration rates from percolation rates.



Percolation Test PT-1

Test Depth: 4.5 ft

Reference point depth: 7.6 ft

Soil Description: **0'-1': Topsoil**

1-4.5'- gray and red fine sandy Clay

Time of Reading	Elapsed time (min.)	initial reading		final reading		percolation rate		Infiltration rate	
		from top of riser, ft	from top of riser, ft	from top of riser, ft	from top of riser, ft	ft/hr	in/hr	Rf	Inf rate (in/hr)
1057	30	4.65		4.66		0.02	0.24	18.67	0.01

Percolation Test PT-2

Test Depth: 4.5 ft

Reference point depth: 7.6 ft

Soil Description: **0'-1': Topsoil**

1-4.5'- gray and red fine sandy Clay

Time of reading	Elapsed time (min.)	initial reading		final reading		percolation rate		Infiltration rate	
		from top of riser, ft	from top of riser, ft	from top of riser, ft	from top of riser, ft	ft/hr	in/hr	Rf	Inf rate (in/hr)
1104	30	5.37		5.40		0.06	0.72	14.29	0.05

Percolation Test PT-3

Test Depth: 2.9 ft

Reference point depth: 5.08 ft

Soil Description: **0'-1': Topsoil**

1-2.9'- gray and red fine sandy Clay

Time of reading	Elapsed time (min.)	initial reading		final reading		percolation rate		Infiltration rate	
		from top of riser, ft	from top of riser, ft	from top of riser, ft	from top of riser, ft	ft/hr	in/hr	Rf	Inf rate (in/hr)
1108	30	3.37		3.38		0.01	0.12	26.37	0.005

APPENDIX B

LABORATORY TESTING

SUMMARY OF MATERIAL PROPERTIES

PROJECT: Parachute Rigging Project
REQUISITION NO: W335JG23001990

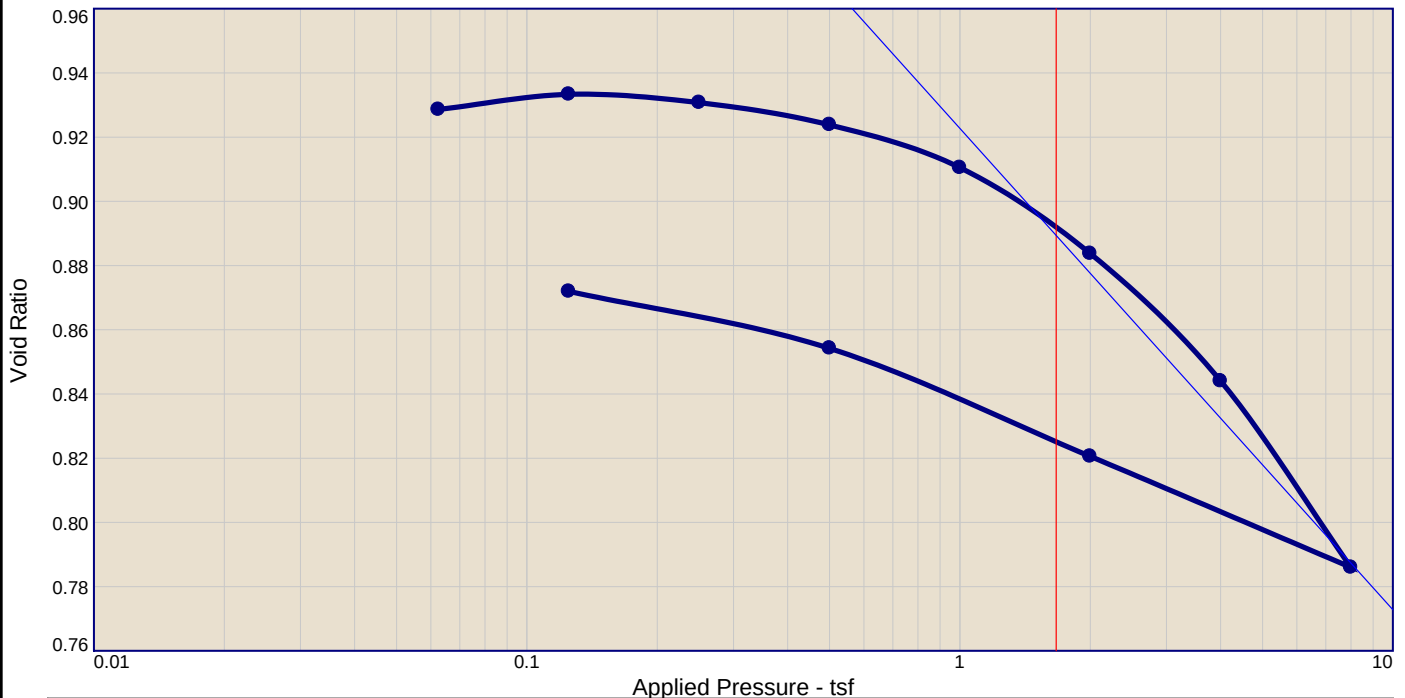
LOCATION: Hunter Army Airfield
WORK ORDER: 6C176J

10-Jan-24

Lab Number	Hole Number	Sample Number	Depth (ft)	ASTM D422 Particle Size Analysis - Percent Passing											D4318 Atterberg Limits			D2216 MC%	Color	Class	D2487 Unified Soil Classification System
				3/4 in %	1/2 in %	3/8 in %	No.4 %	No.10 %	No.20 %	No.40 %	No.60 %	No.100 %	No.140 %	No 200 %	LL	PL	PI				
K6/18851	B-1	S-2	2.0 to 3.5					100	99.8	99.1	96.4	84.2	70.4	64.8	61	20	41	18.76	Light Brownish Gray, Light Gray, Reddish Yellow & Brown	CH	Sandy Fat Clay (CH).
K6/18855	B-1	S-6	13.5 to 15.0				100	99.9	99.7	98.8	97.8	93.2	69.3	38.3	38	18	20	37.35	Gray & Pale Brown	SC	Clayey Sand (SC).
K6/18856	B-1	S-7	18.5 to 20.0					100	100	99.9	99.7	95.7	72.6	50	43	19	24	48.97	Dark Gray & Reddish Brown	CL	Sandy Lean Clay (CL).
K6/18857	B-1	S-8	23.5 to 25.0			100	98.3	91.2	73.4	36.3	10.4	6.8	4.8	4	NP	NP	NP	17.31	Dark Gray, Gray & Light Brownish Gray	SP	Poorly Graded Sand (SP), with a trace of gravel.
K6/18859	B-1	S-10	33.5 to 35.0	100	91.9	91.9	91.5	90.4	88.2	86.5	85.6	69	21.9	11.6	51	21	30	34.57	Dark Gray	SP-SC	Poorly Graded Clayey Sand (SP-SC), with a trace of gravel.
K6/18862	B-1	S-13	48.5 to 50.0				100	99.9	99	98.1	97.6	81.3	28.4	13.1	NP	NP	NP	34.24	Dark Gray & Light Grayish Brown	SM	Silty Sand (SM).
K6/18847	B-1A	ST-1	4.0 to 6.0					100	99.4	97.5	93	85.6	80.9	79	96	28	68	28.79	Gray, Light Gray & Reddish Brown	CH	Fat Clay (CH), with some sand.
K6/18848	B-1A	ST-2	18.0 to 20.0					100	99.9	99.8	99.4	96	74.2	47.5	51	19	32	49.45	Gray & Light Gray	SC	Clayey Sand (SC).
K6/18867	B-2	S-5	8.0 to 9.5					100	99.9	99.7	98.8	58.4	22.9	19.1	NP	NP	NP	20.84	Gray, Light Brownish Gray, Yellow & Reddish Yellow	SM	Silty Sand (SM).
K6/18869	B-2	S-7	18.5 to 20.0				100	94.3	85.1	72.9	64	51.3	32.6	24.9	41	22	19	32.58	Dark Gray & Light Yellowish Brown	SC	Clayey Sand (SC).
K6/18874	B-3	S-2	2.0 to 3.5				100	99.7	99.4	97.7	91.4	58.6	35.6	29.1	29	15	14	13.04	Very Dark Grayish Brown, Pale Brown, Gray & Yellowish Red	SC	Clayey Sand (SC).
K6/18879	B-3	S-7	18.5 to 20.0				100	99.9	99.9	99.8	99.2	51.7	15.1	11.6				27.69	Gray & Light Yellowish Brown	SP-SM	Poorly Graded Silty Sand (SP-SM).
K6/18881	B-3	S-9	28.5 to 30.0			100	99.2	98.7	98.1	97	94.9	80.3	41.8	26.4	34	19	15	37.04	Dark Gray	SC	Clayey Sand (SC).
K6/18849	B-5	ST-1	8.0 to 10.0					100	100	99.9	99.7	96.1	83.1	73.3	45	18	27	22.72	Gray, Light Gray & Reddish Yellow	CL	Lean Clay (CL), with some sand.
K6/18898	B-5	S-9	28.5 to 30.0			100	99.4	94.9	73.7	29.7	16.8	12.4	9	7.3				18.78	Dark Gray & Light Brownish Gray	SP-SM	Poorly Graded Silty Sand (SP-SM).
K6/18901	B-6	S-3	4.0 to 5.5					100	99.9	99.4	96	71.6	48.7	42.8	39	14	25	19	Light Gray & Yellowish Brown	SC	Clayey Sand (SC).
K6/18903	B-6	S-5	8.0 to 9.5					100	100	99.9	99.6	64.4	30.2	26.2	30	21	9	21.05	Pale Brown & Gray	SC	Clayey Sand (SC).
K6/18906	B-6	S-8	23.5 to 25.0			100	99.2	87.7	57.6	33.3	22.9	14	7.1	4.8	32	18	14	10.75	Grayish Brown & Dark Gray	SW-SC	Well Graded Clayey Sand (SW-SC).
K6/18909	B-6	S-11	38.5 to 40.0				100	99.1	96.4	93.9	93.3	81.3	27.8	11.5	NP	NP	NP	33.03	Grayish Brown & Dark Gray	SP-SM	Poorly Graded Silty Sand (SP-SM).
K6/18912	B-7	S-2	2.0 to 3.5					100	99.9	99.5	97.2	77	58.1	50.1	45	16	29	24.97	Brownish Yellow, Grayish Brown, Dark Brown & Gray	CL	Sandy Lean Clay (CL).
K6/18919	B-8	S-4	6.0 to 7.5					100	99.6	99.5	99	81	44.5	37.4	36	15	21	20.73	Light Gray, Pale Brown, Gray & Reddish Yellow	SC	Clayey Sand (SC).
K6/18922	B-8	S-7	18.5 to 20.0				100	100	99.9	99.7	98	33.1	8.1	6	NP	NP	NP	27.55	Light Yellowish Brown, Light Brownish Gray & Dark Gray	SP-SM	Poorly Graded Silty Sand (SP-SM).
K6/18923	B-8	S-8	23.5 to 25.0			100	99.8	98.8	92.8	76.9	62.2	31.8	20.5	17.3	32	16	16	28.39	Dark Gray, Gray, Light Gray & Light Yellowish Brown	SC	Clayey Sand (SC).
K6/18925	B-8	S-10	33.5 to 35.0				100	99.6	96.6	94.8	93.9	71.2	21.2	12	50	37	13	34.07	Dark Gray, Gray & Light Gray	SP-SM	Poorly Graded Silty Sand (SP-SM).

US Army Corps of Engineers - Marietta, GA 30062

CONSOLIDATION TEST REPORT ASTM D2435



Coefficients of Consolidation and Secondary Consolidation

No.	Load (tsf)	C _v (ft. ² /day)	C _α	No.	Load (tsf)	C _v (ft. ² /day)	C _α	No.	Load (tsf)	C _v (ft. ² /day)	C _α
1	0.06	swell		8	8.00	0.028	0.007				
2	0.13	swell									
3	0.25	swell									
4	0.50	-----	-----								
5	1.00	0.018	0.001								
6	2.00	0.049	0.003								
7	4.00	0.029	0.005								

MATERIAL DESCRIPTION

Gray, Light Gray & Reddish Brown, Fat Clay (CH), with some sand.

USCS

CH

AASHTO

LL	PI	Sp. Gr.	Init. Eff. Stress (tsf)	Dry Density (pcf)		Moisture		Saturation		Void Ratio		P _c (tsf)	C _c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
96	68	2.65	0.287	86.2		33.4 %	34.4 %	96.3 %	100.0 %	0.920	0.872	1.75	0.163

Preparation Process:

Condition of Test: Inundated

D2435 Method

A

C_r

0.05

Swell Press. (tsf)

Swell %

Project No. W33SJG23001990, Client: Savannah District

Project: Parachute Rigging, Hunter Army Airfield

Loc.: B-1A, ST-1, 4.0 - 6.0', K6/18847

Depth: 4.0 - 6.0'

Sample No.: ST-1

Remarks:

Other tests were done in general accordance with ASTM's: D422, D2216, D2435, D2487

Checked By: MW

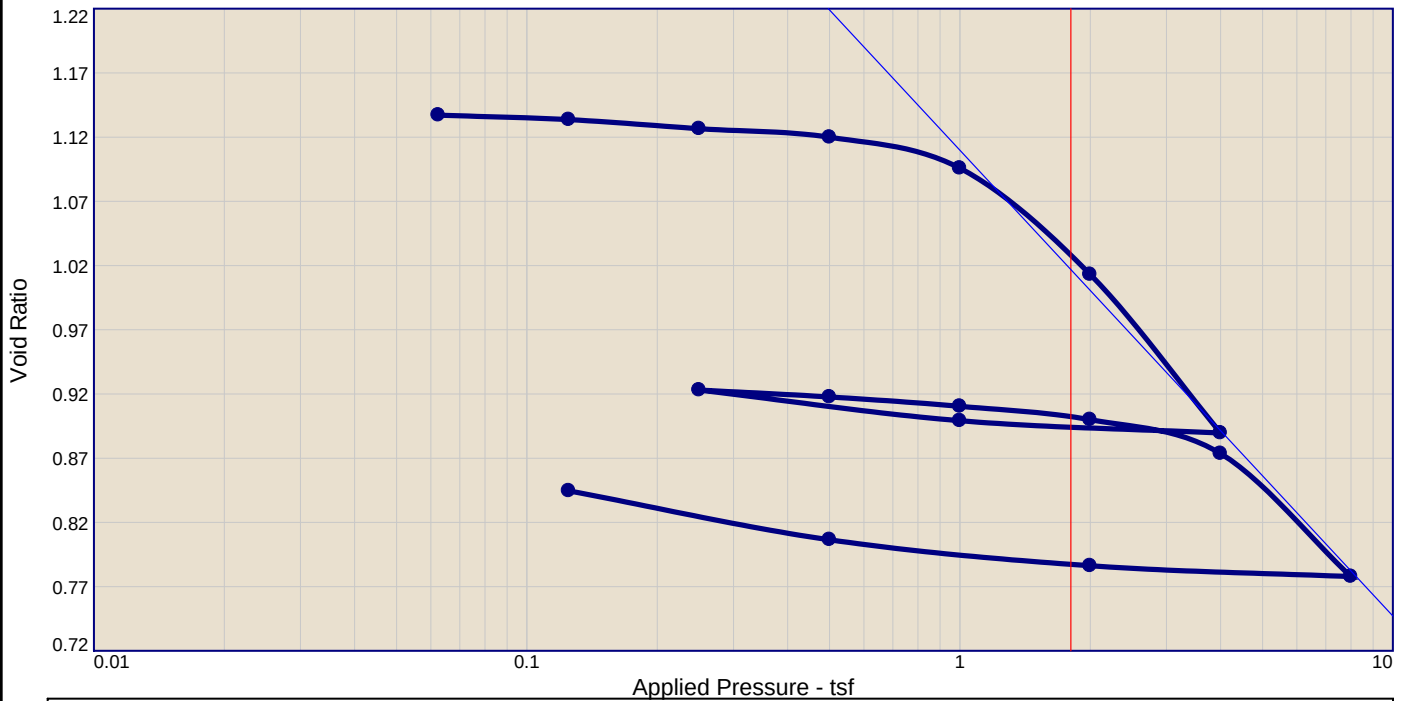
Title:

Figure

U.S. Army Corp of Engineers

Tested By: ML

CONSOLIDATION TEST REPORT ASTM D2435



Coefficients of Consolidation and Secondary Consolidation

No.	Load (tsf)	C _v (ft. 2/day)	C _α	No.	Load (tsf)	C _v (ft. 2/day)	C _α	No.	Load (tsf)	C _v (ft. 2/day)	C _α
1	0.06	1.182	0.000	10	0.50	0.067	0.000				
2	0.13	0.190	0.000	11	1.00	0.210	0.001				
3	0.25	0.528	0.001	12	2.00	0.580	0.001				
4	0.50	0.408	0.001	13	4.00	0.777	0.003				
5	1.00	0.319	0.003	14	8.00	0.364	0.008				
6	2.00	0.246	0.008								
7	4.00	0.387	0.011								

MATERIAL DESCRIPTION

USCS

AASHTO

Gray & Light Gray, Clayey Sand (SC).

SC

LL	PI	Sp. Gr.	Init. Eff. Stress (tsf)	Dry Dens. (pcf)		Moisture		Saturation		Void Ratio		P _c (tsf)	C _c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
51	32	2.65	0.718	77.0		39.0 %	32.2 %	90.0 %	100.0 %	1.148	0.845	0.8	0.355

Preparation Process:

D2435 Method

C_r

Swell Press. (tsf)

Swell %

Condition of Test: Inundated

A

0.04

Project No. W33SJG23001990, Client: Savannah District

Project: Parachute Rigging, Hunter Army Airfield

Loc.: B-1A, ST-2, 18.0 - 20.0', K6/18848

Depth: 18.0 - 20.0'

Sample No.: ST-2

Remarks:

Other tests were done in general accordance with ASTM's: D422, D2216, D2435, D2487

Checked By: MW

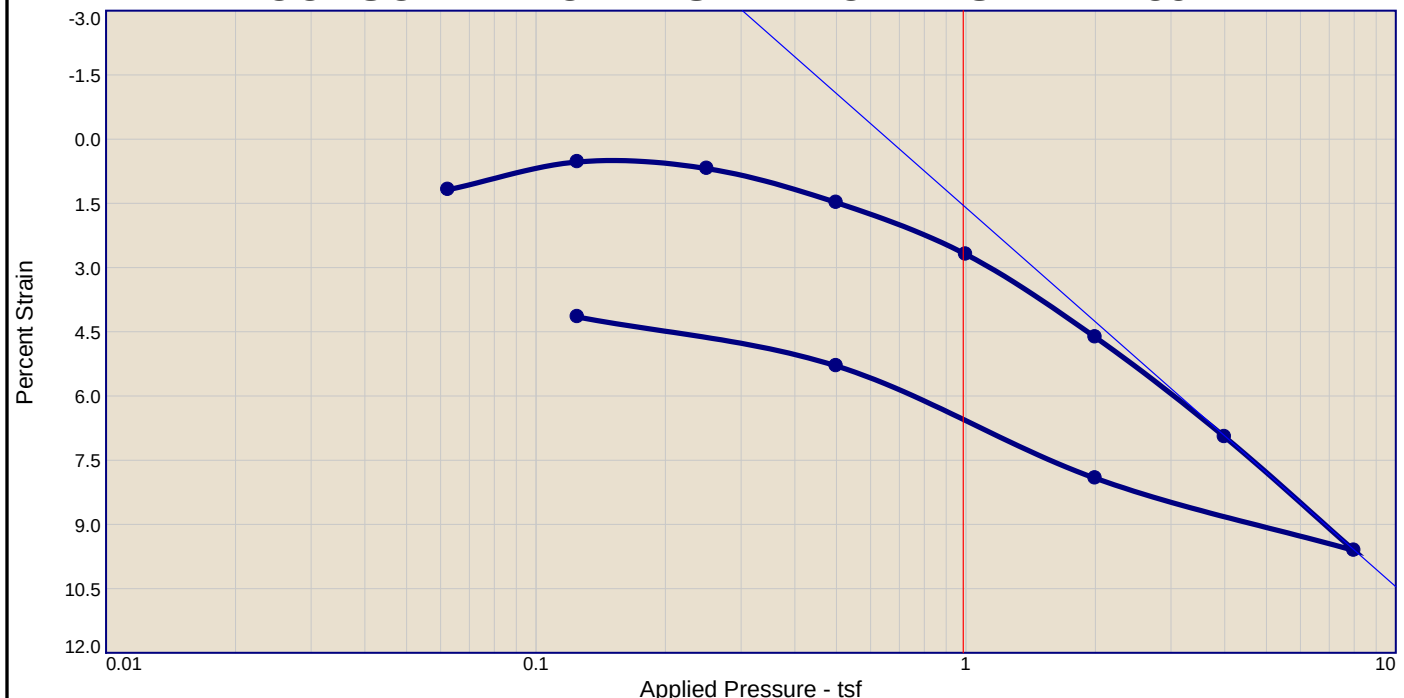
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Figure

U.S. Army Corp of Engineers

Tested By: ML

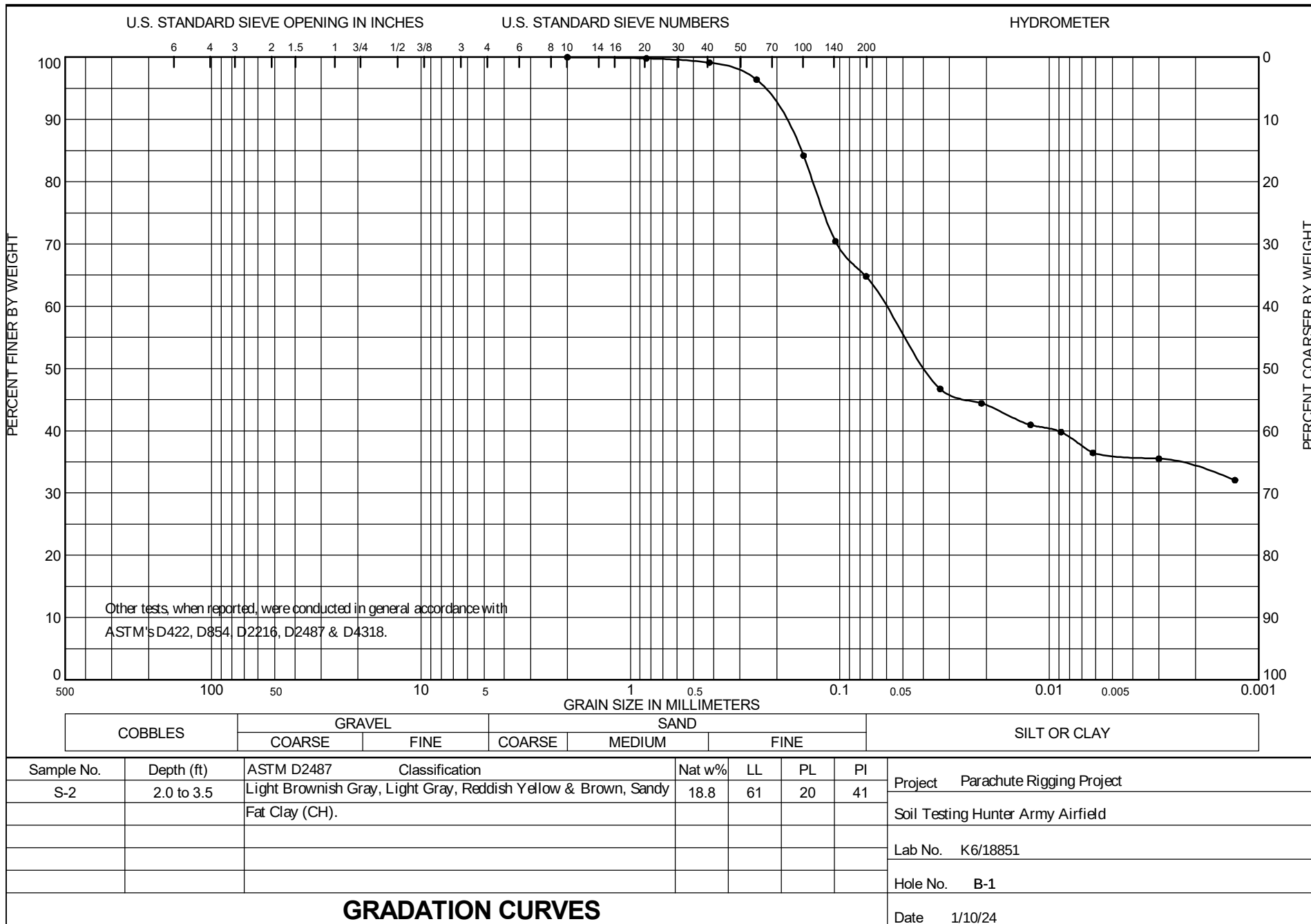
CONSOLIDATION TEST REPORT ASTM D2435



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (tsf)	C _v (ft. ² /day)	C _α	No.	Load (tsf)	C _v (ft. ² /day)	C _α	No.	Load (tsf)	C _v (ft. ² /day)	C _α
1	0.06	swell	-----	8	8.00	0.007	0.007				
2	0.13	swell	-----								
3	0.25	0.014	0.000								
4	0.50	0.013	0.002								
5	1.00	0.013	0.004								
6	2.00	0.010	0.006								
7	4.00	0.010	0.008								

MATERIAL DESCRIPTION										USCS	AASHTO		
Gray, Light Gray & Reddish Brown, Lean Clay (CL), with some sand.										CL			
LL	PI	Sp. Gr.	Overburden (tsf)	Dry Dens. (pcf)		Moisture		Saturation		Void Ratio		P _c (tsf)	C _c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
45	27	2.65		97.2		26.2 %	27.9 %	98.8 %	100.0 %	0.702	0.631	0.67	0.15
Preparation Process:									D2435 Method	C _r	Swell Press. (tsf)	Swell %	
Condition of Test: Inundated									ASTM	0.05			
Project No. W33SJG23001990, Client: Savannah District									Remarks:				
Project: Parachute Rigging, Hunter Army Airfield									Other tests were done in general accordance with ASTM's: D422, D2216, D2435, D2487				
Loc.: B-5, ST-1, 8.0 - 10.0', K6/18849 Depth: 8.0 - 10.0' Sample No.: ST-1									Checked By: MW				
U.S. Army Corp of Engineers									Title:				
									Figure				

Tested By: ML

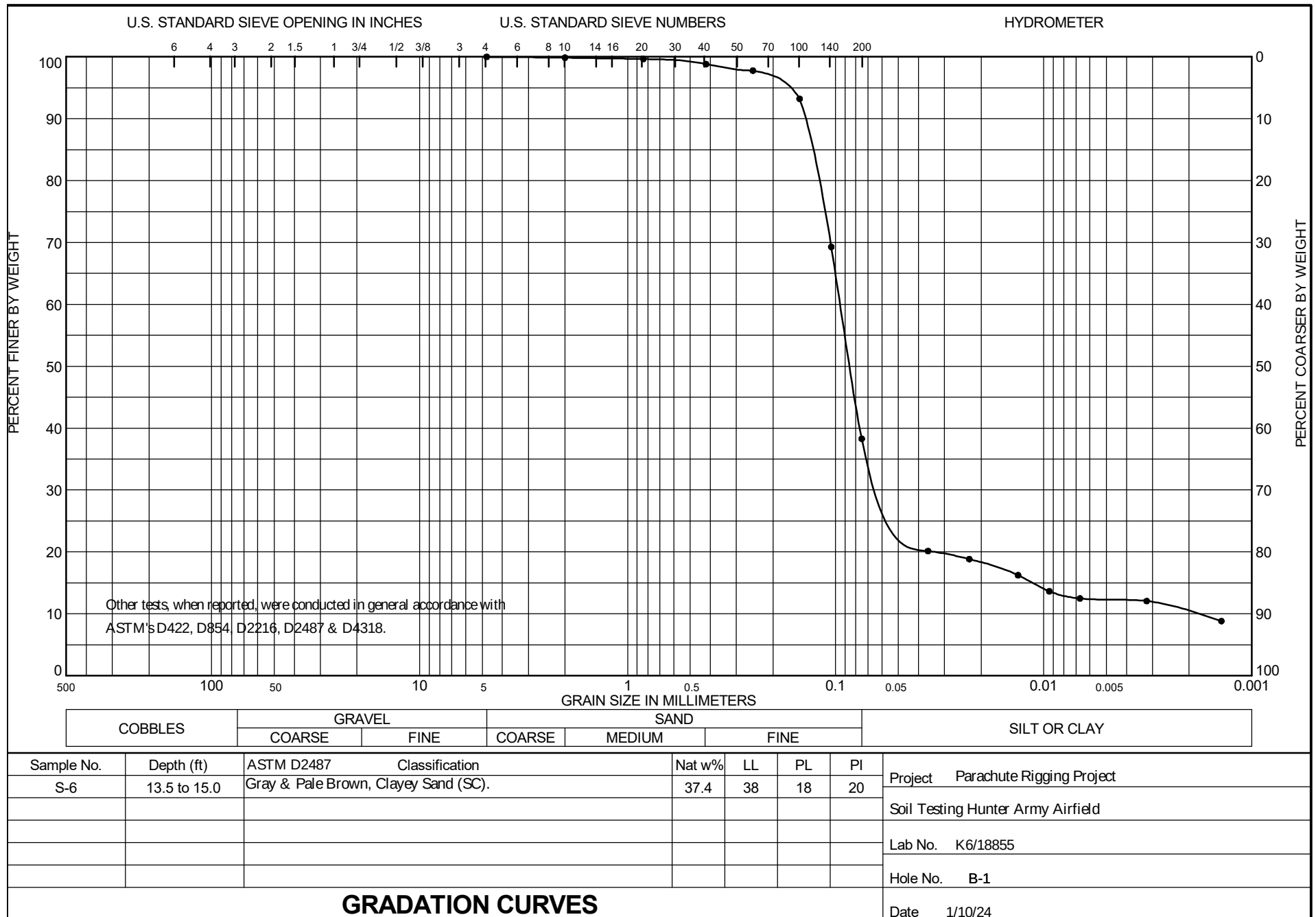


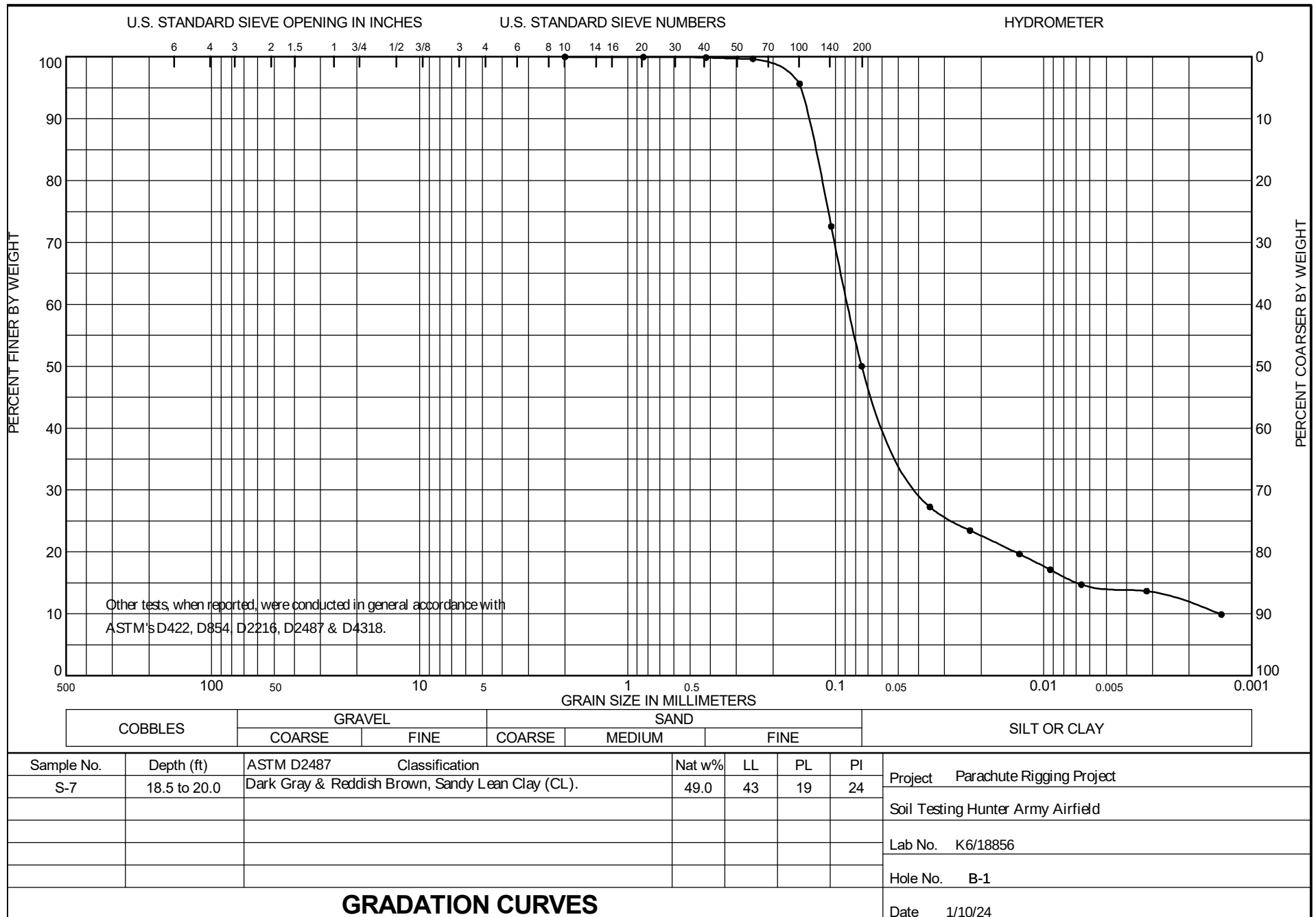


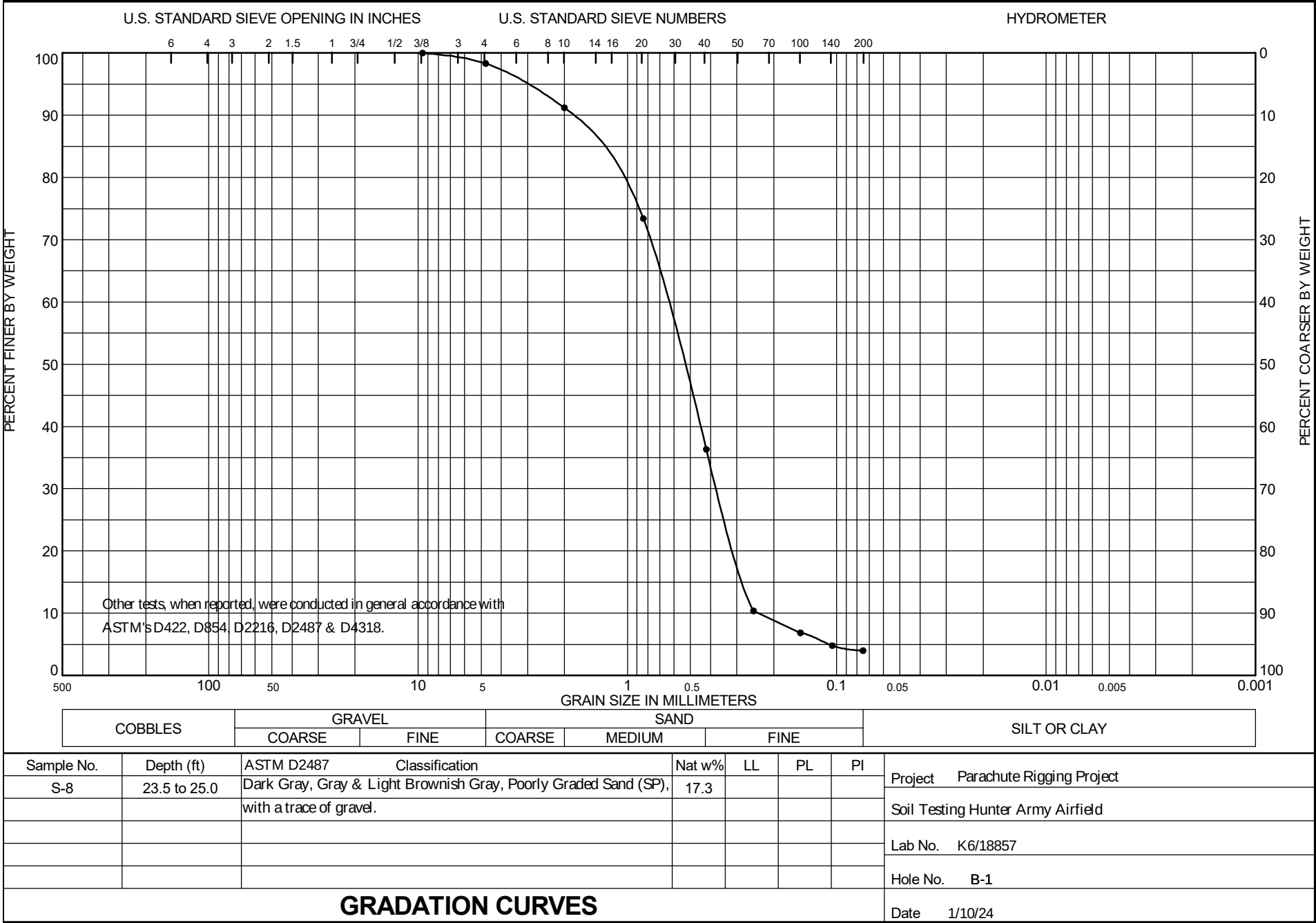
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CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 6C176J

REQUISITION: W33SJG23001990





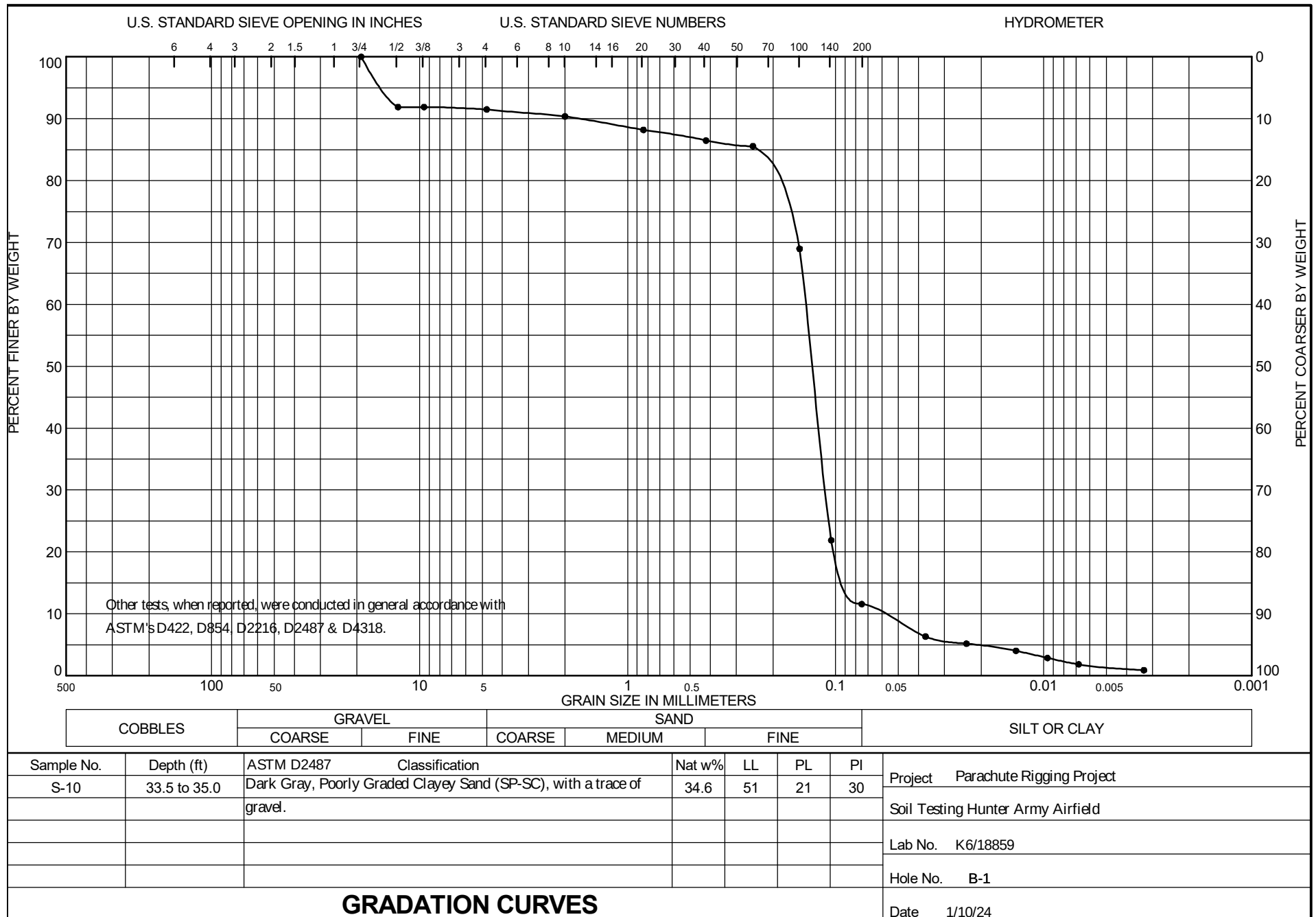


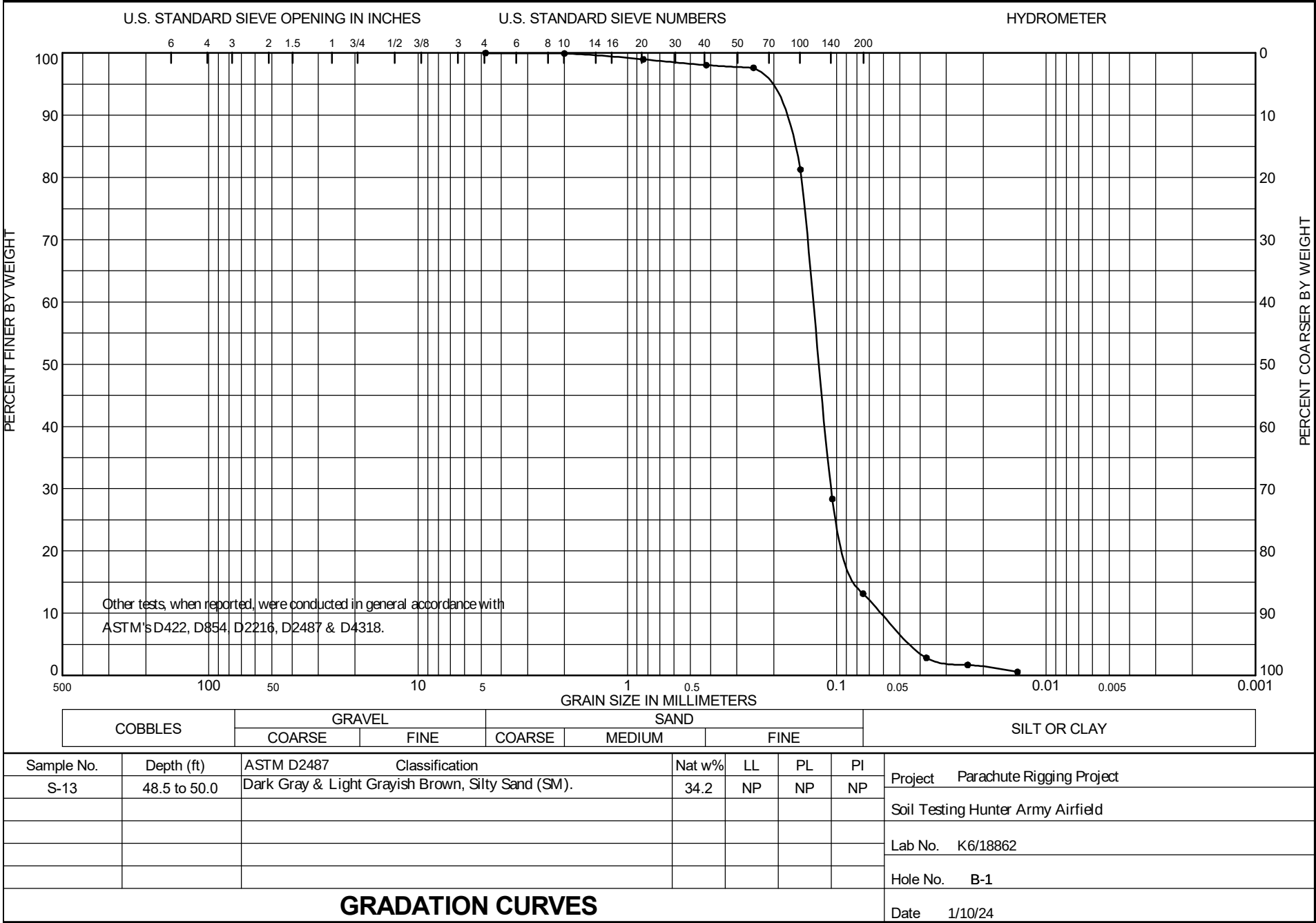


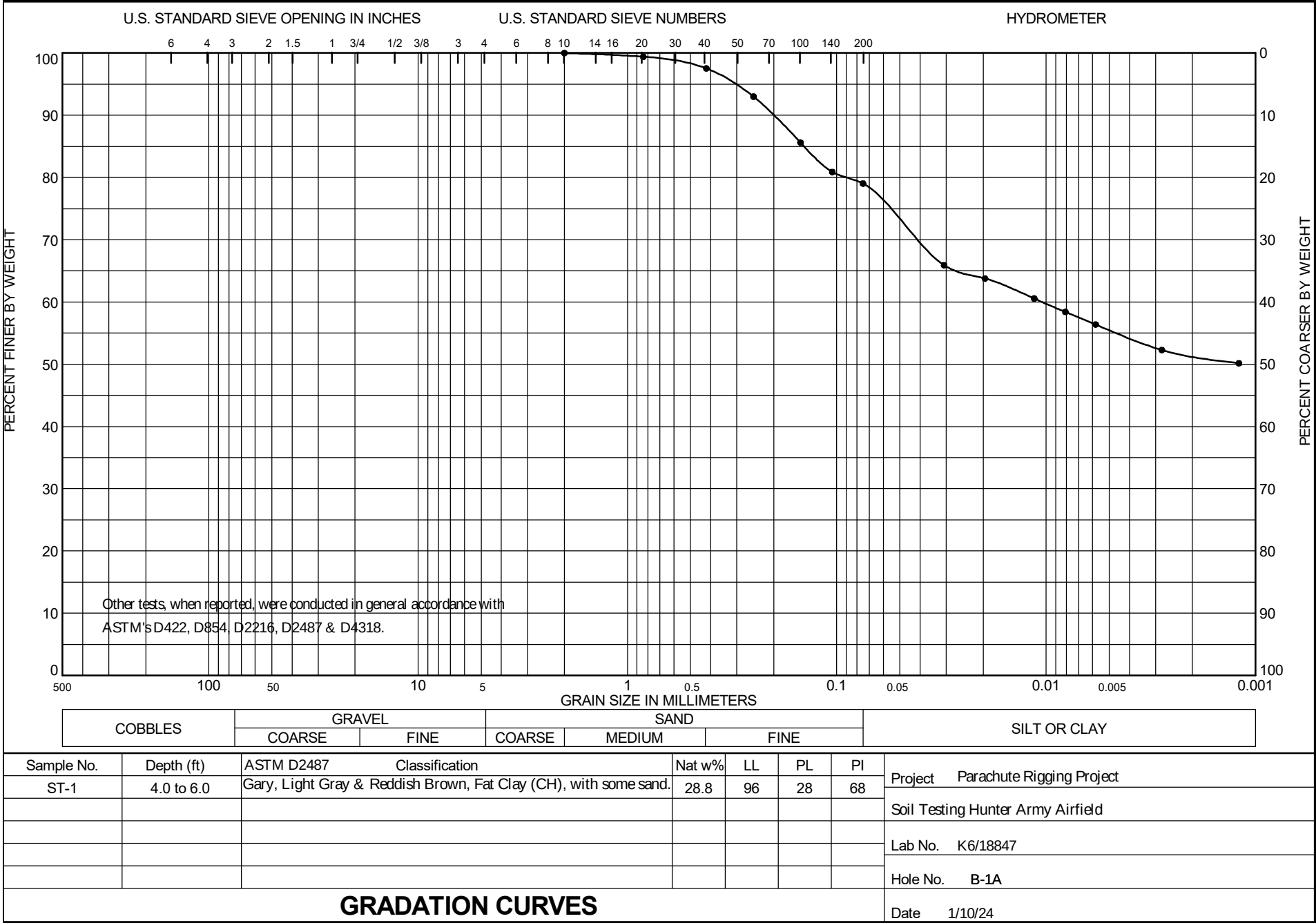
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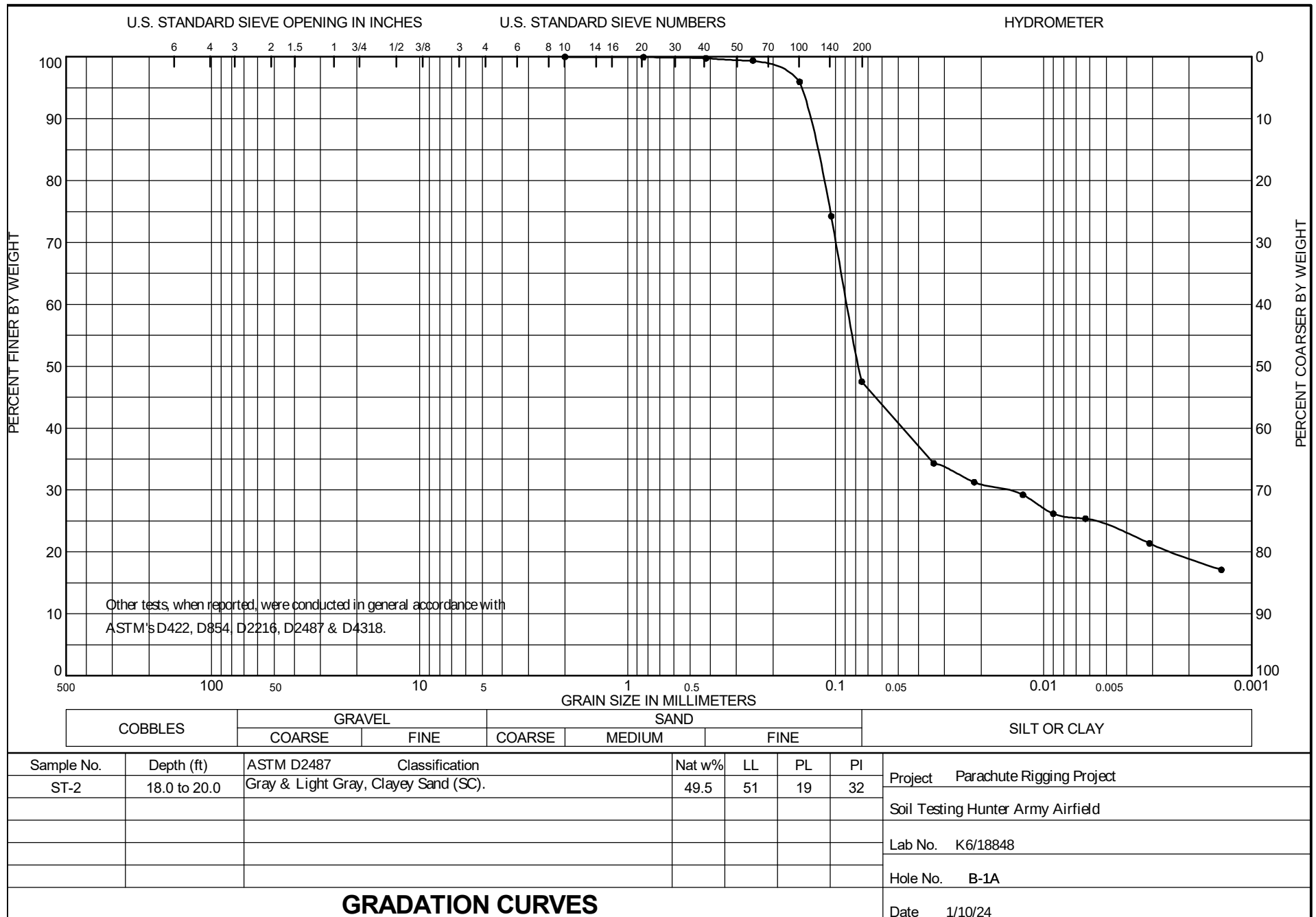


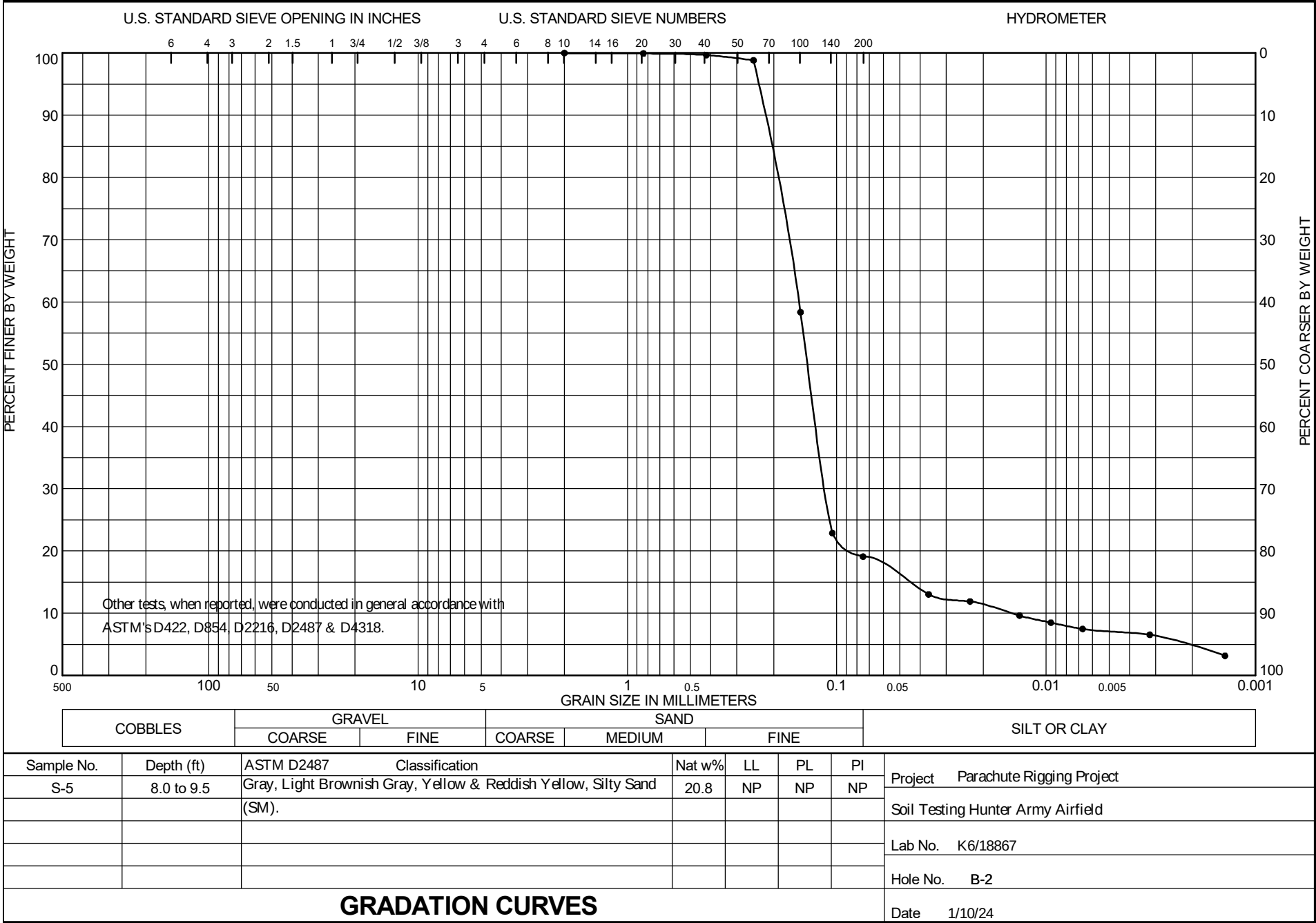


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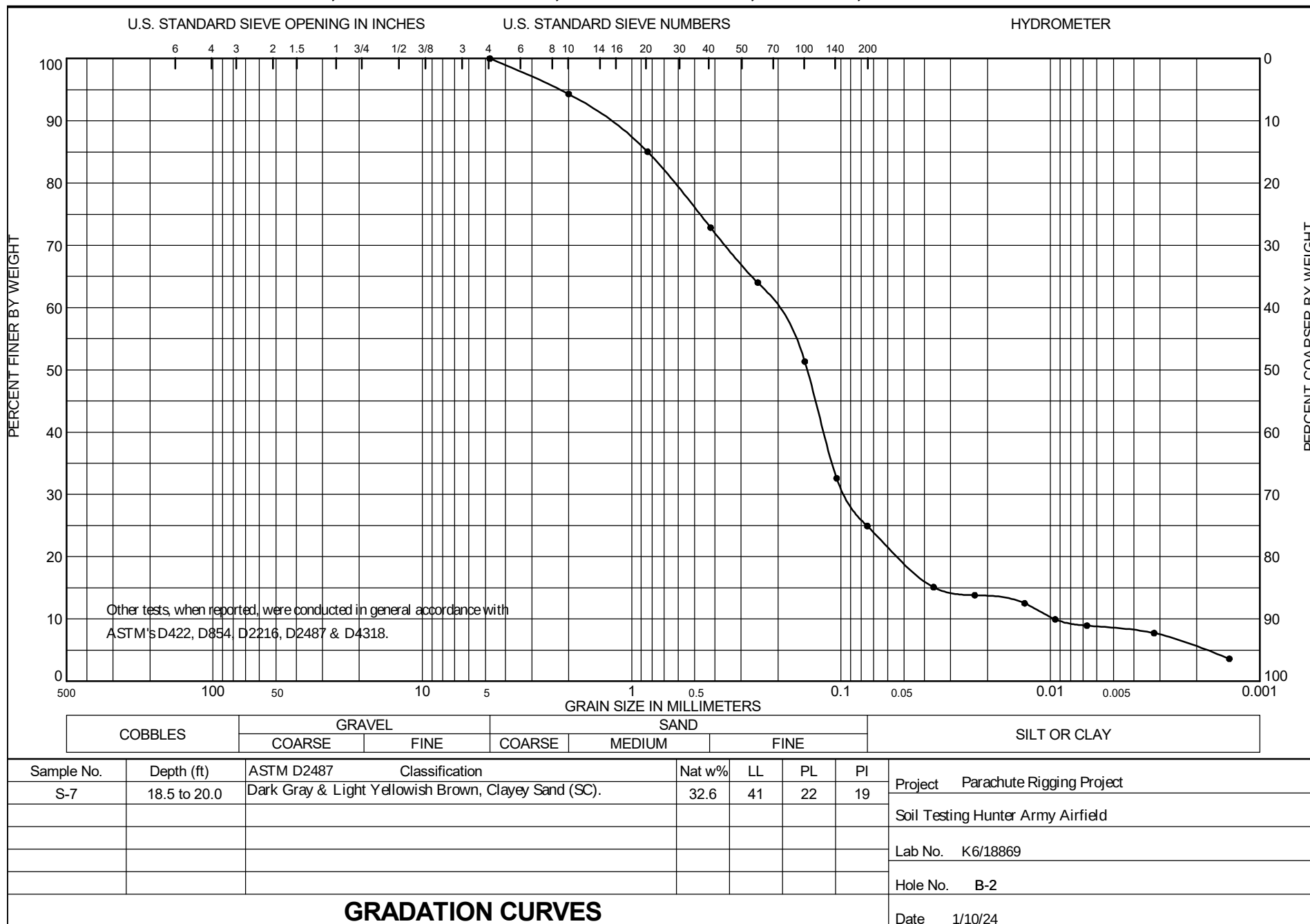


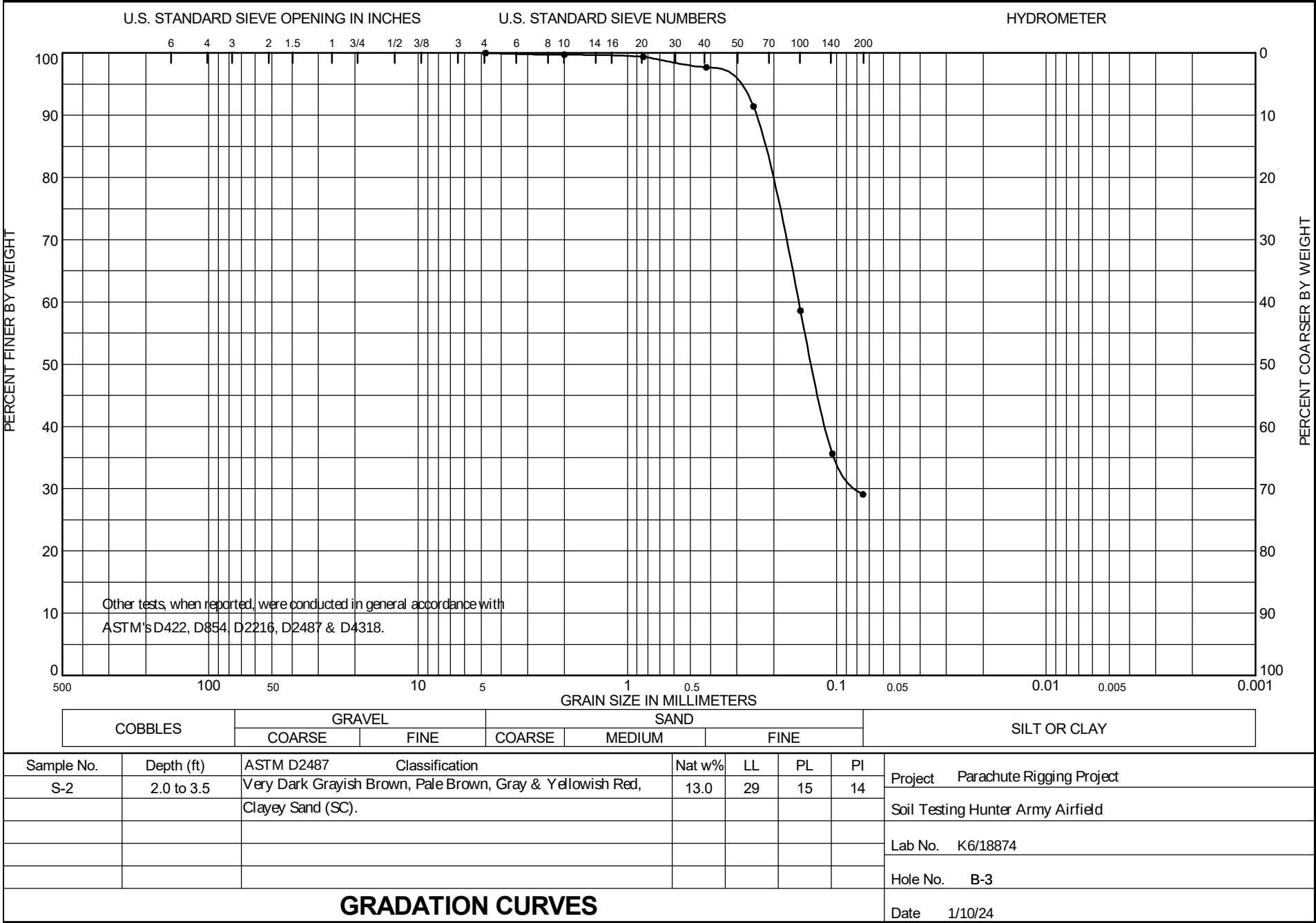


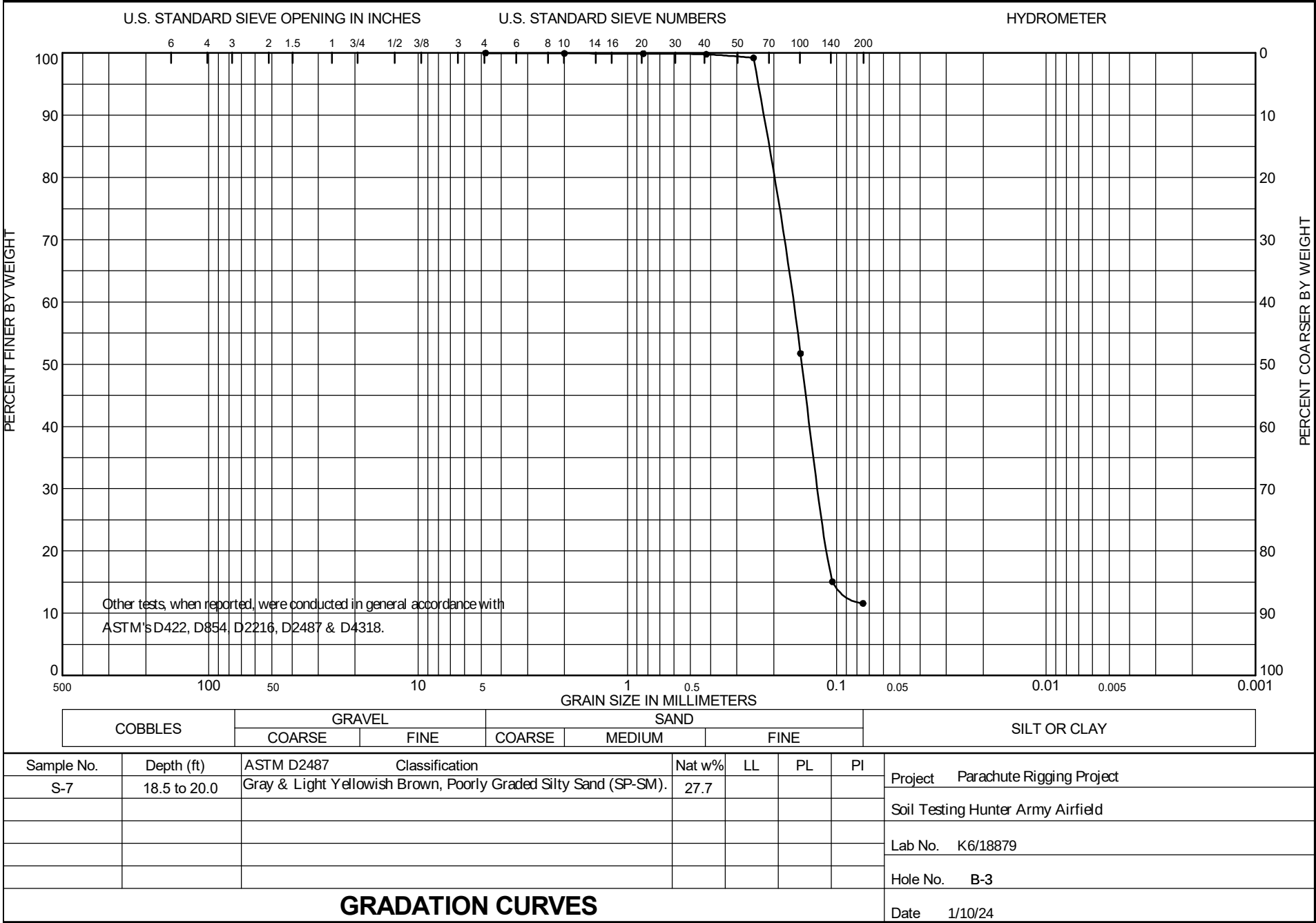
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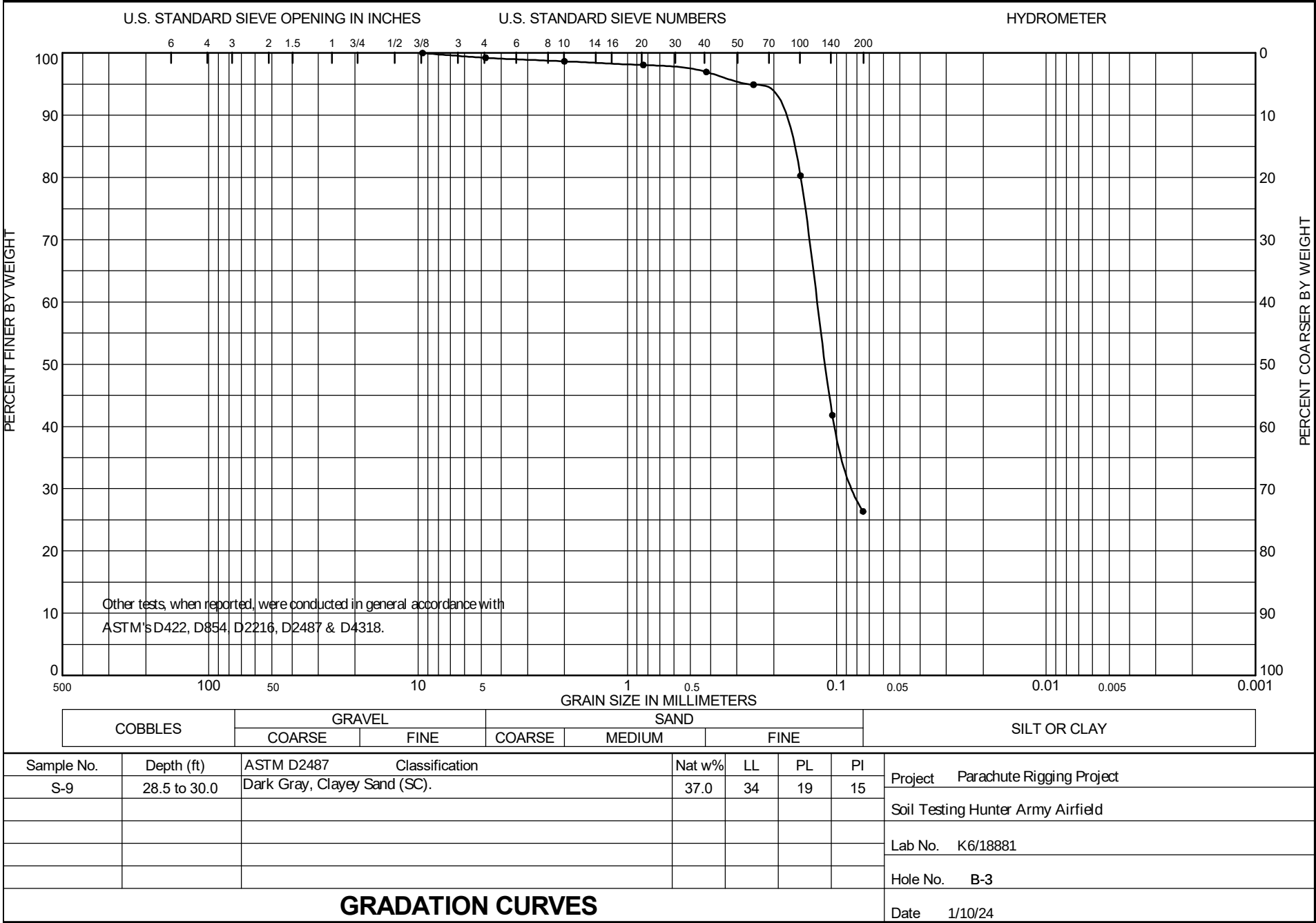
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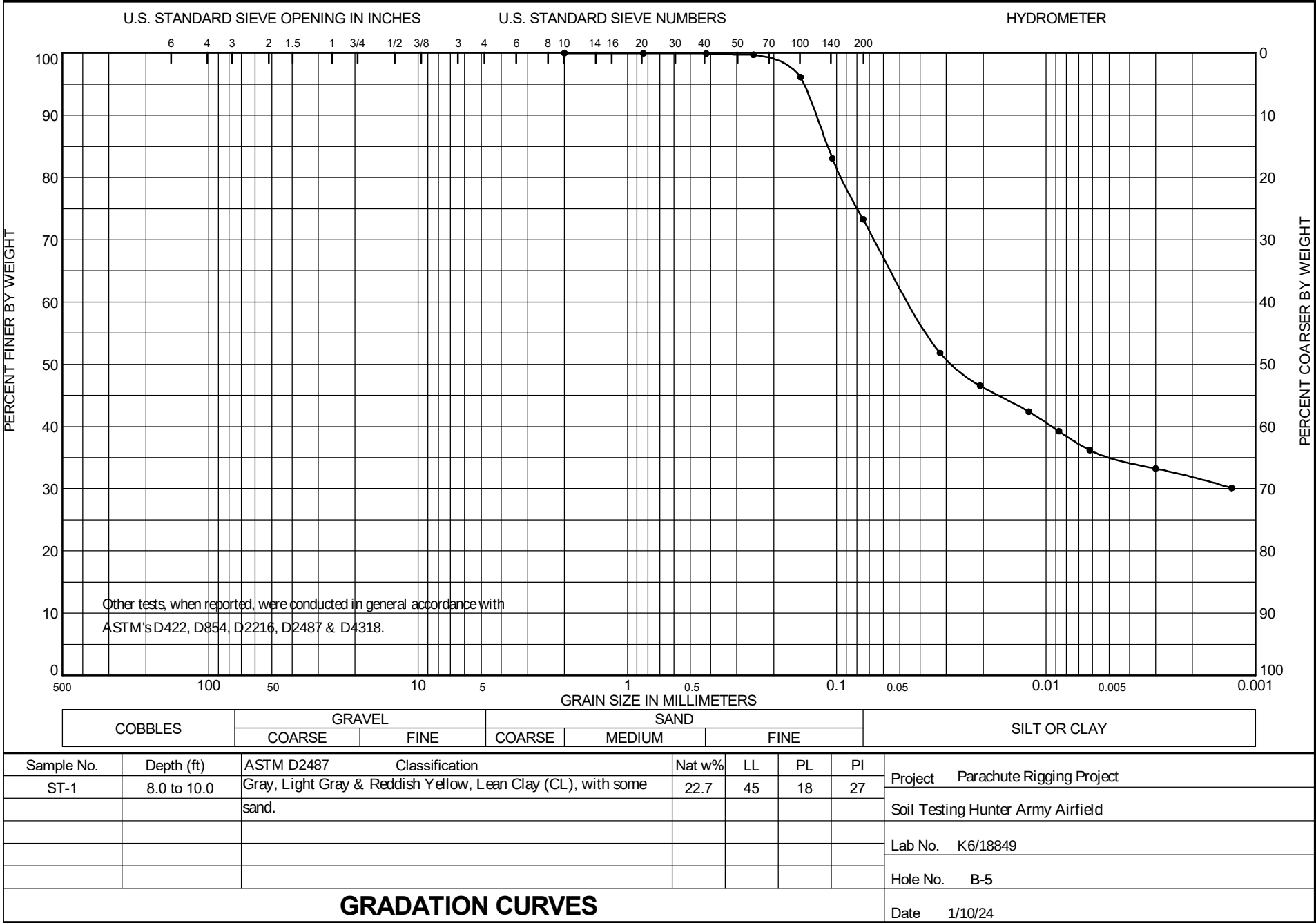
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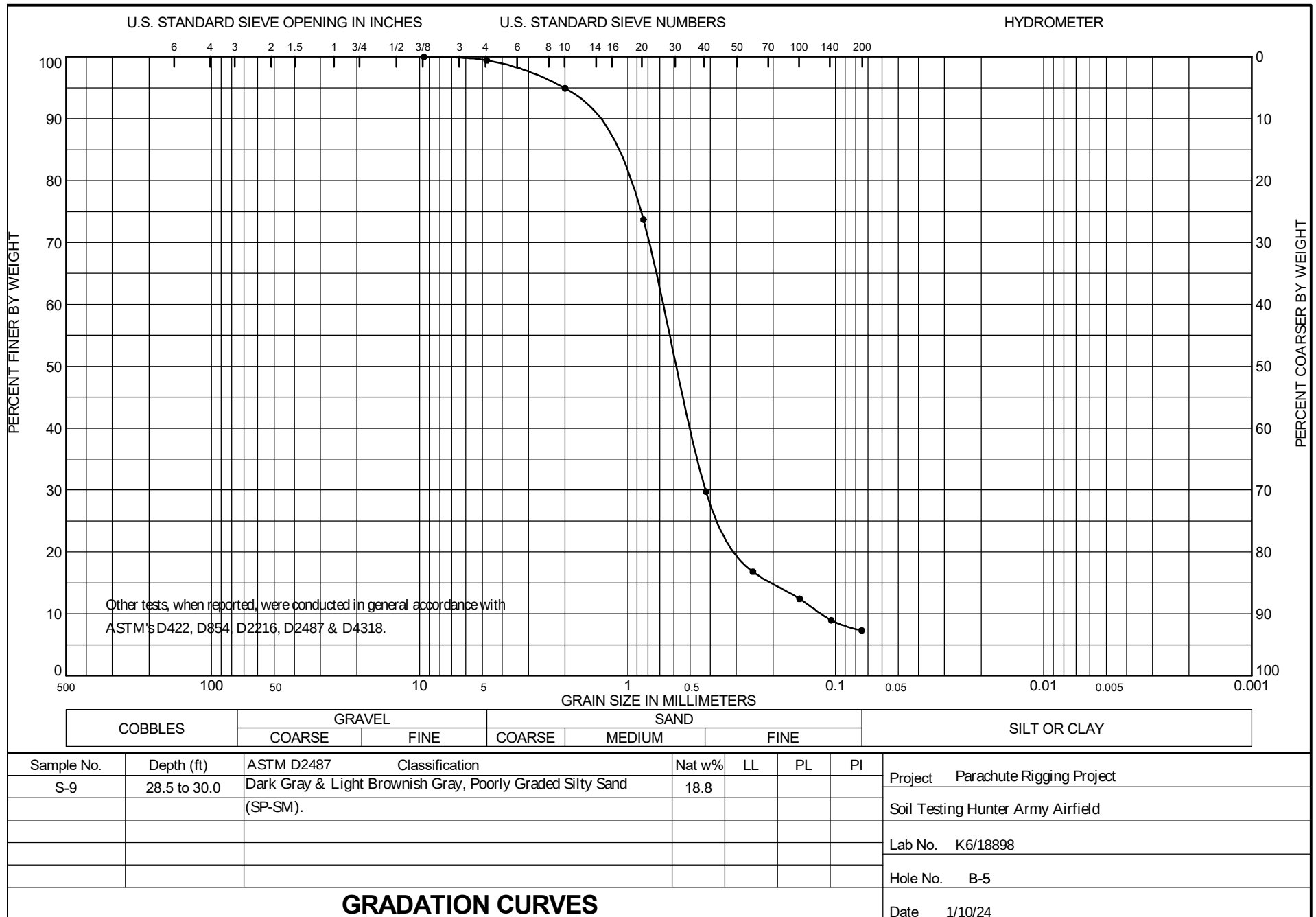


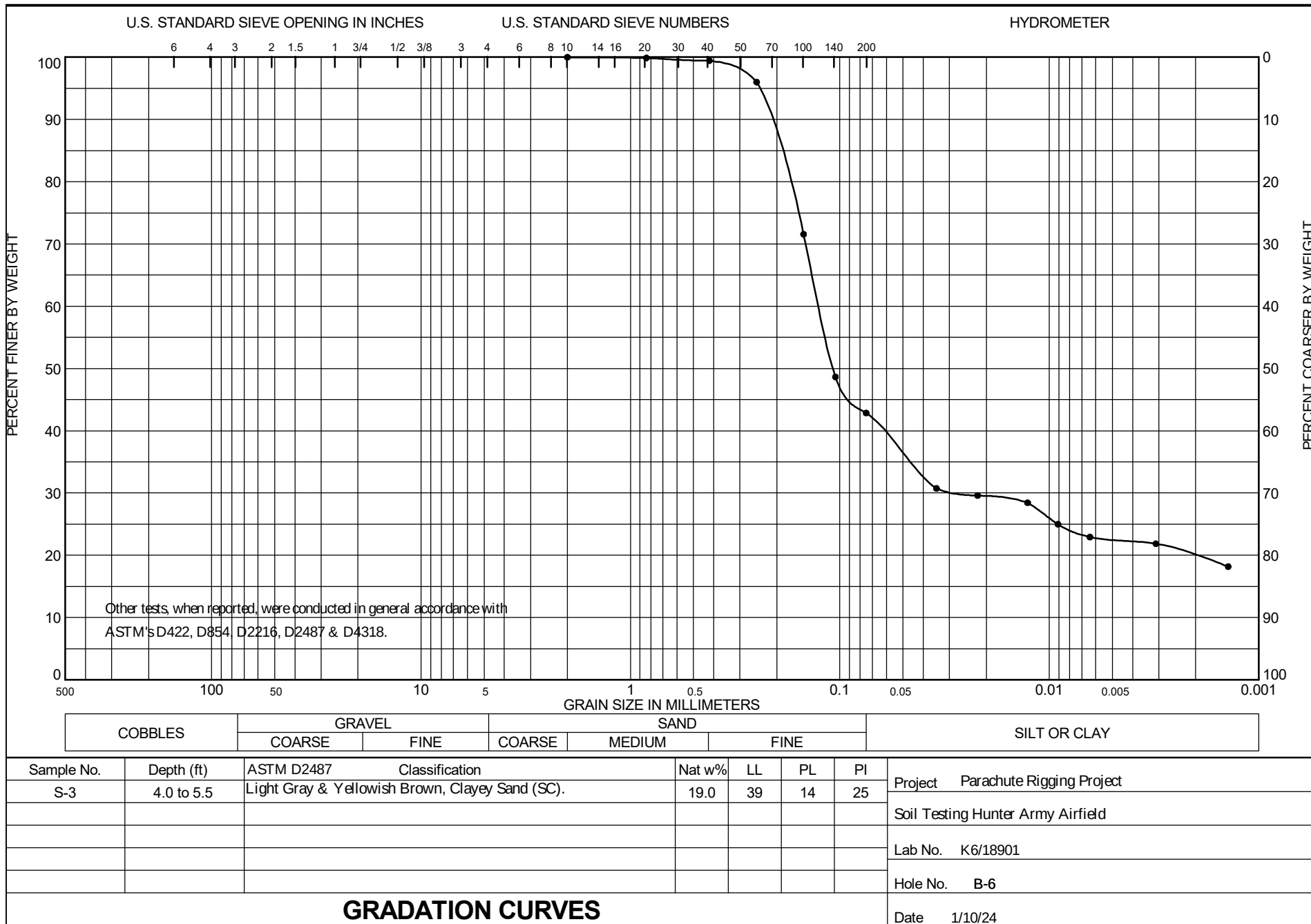


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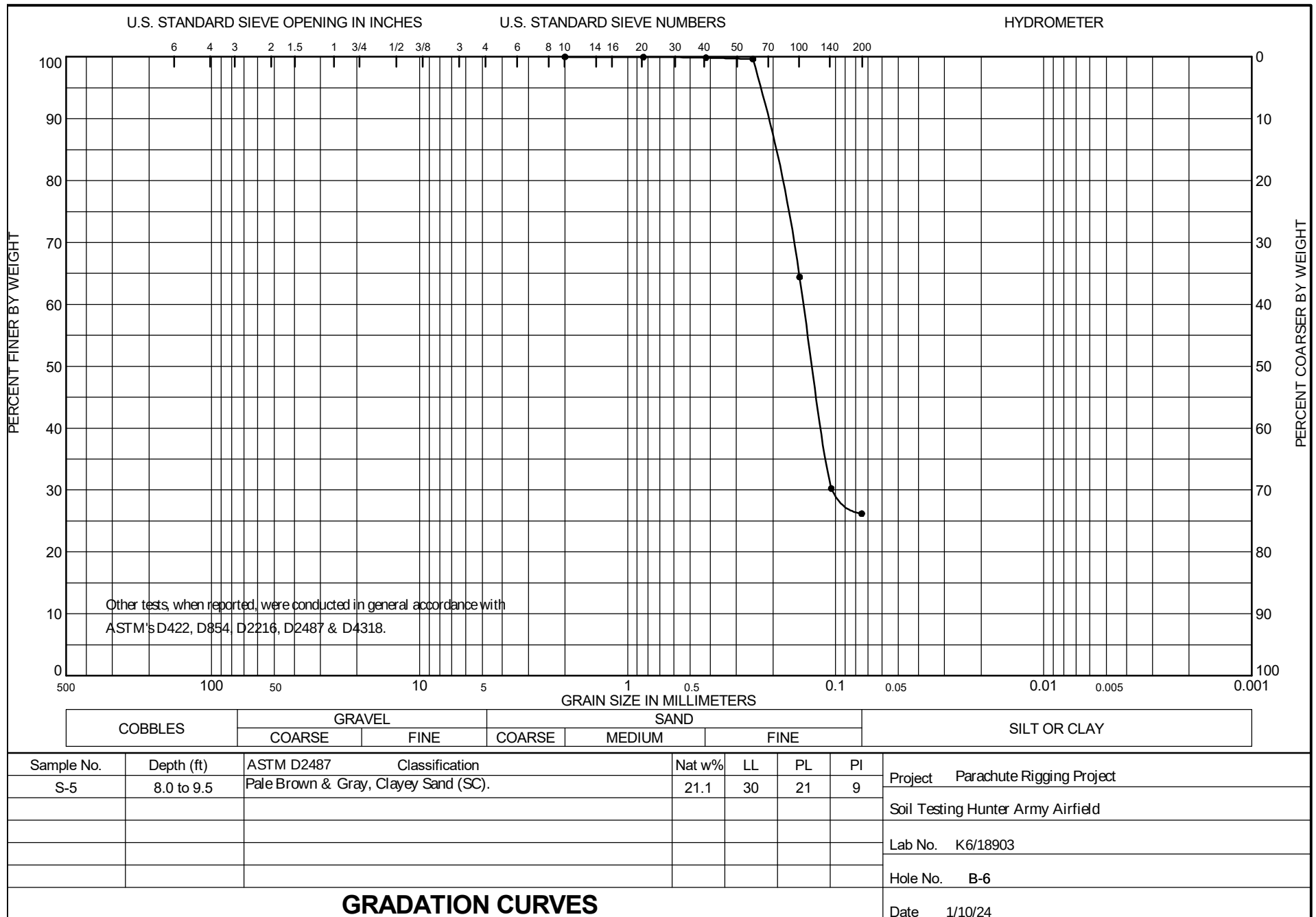


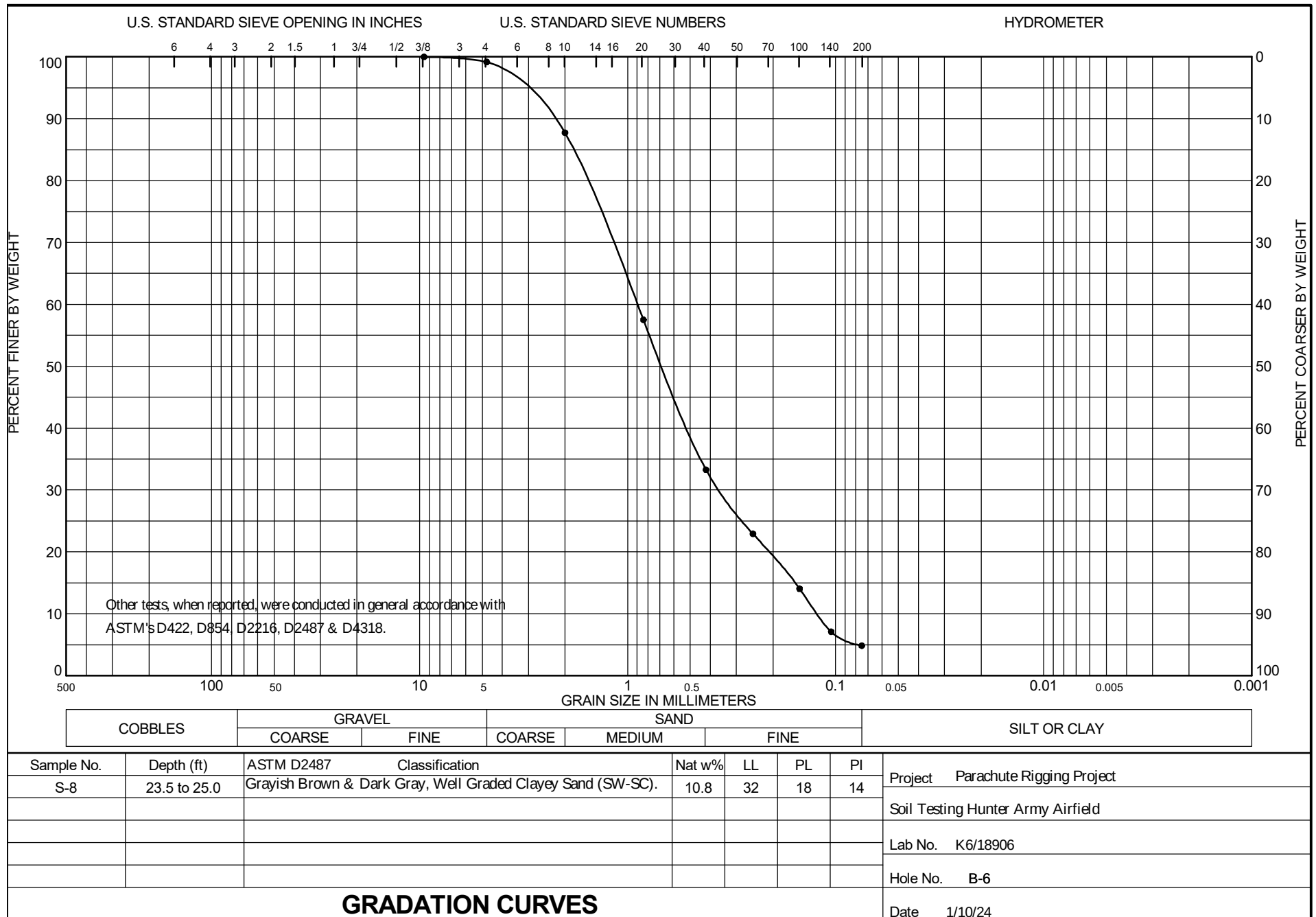


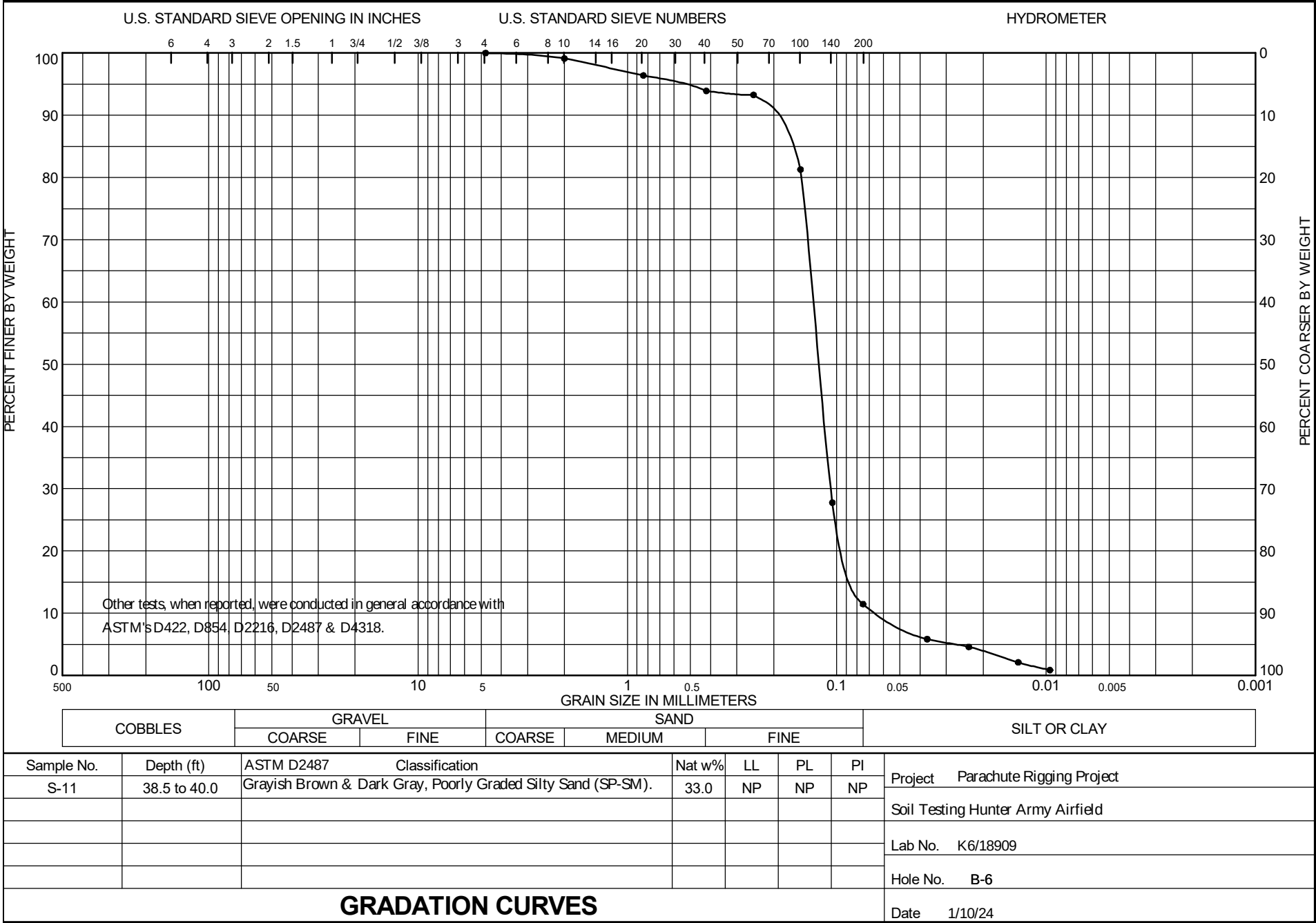
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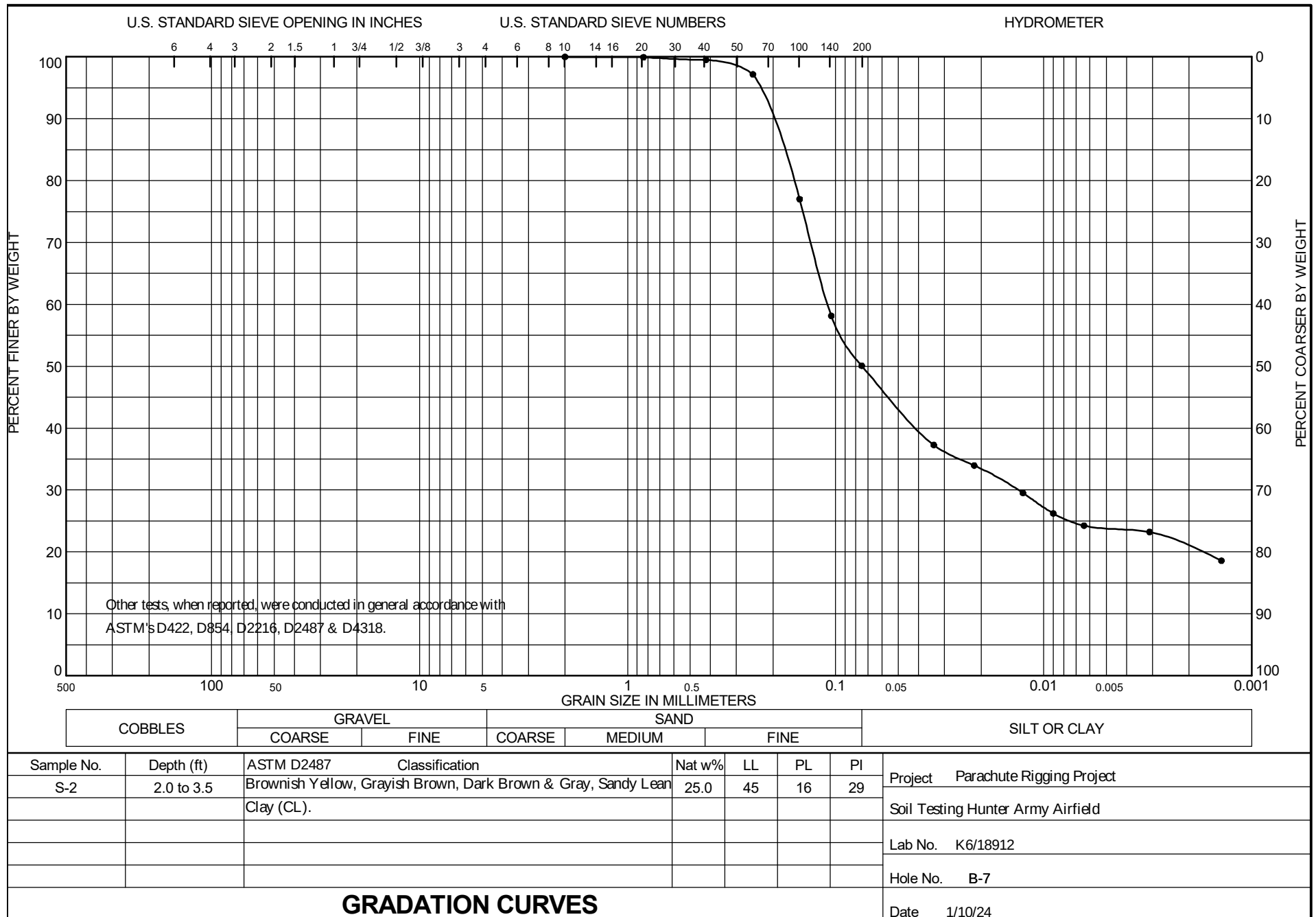




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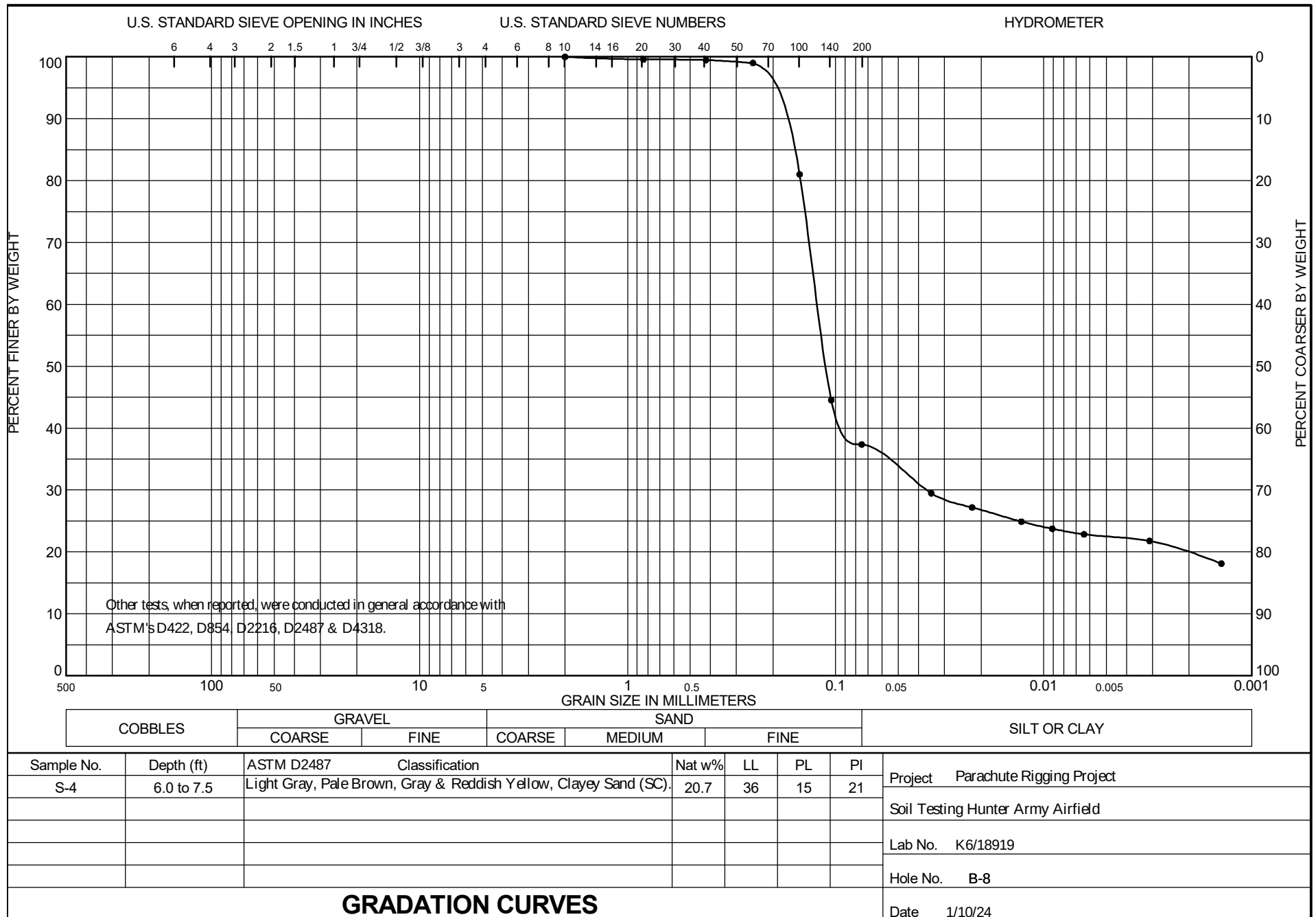


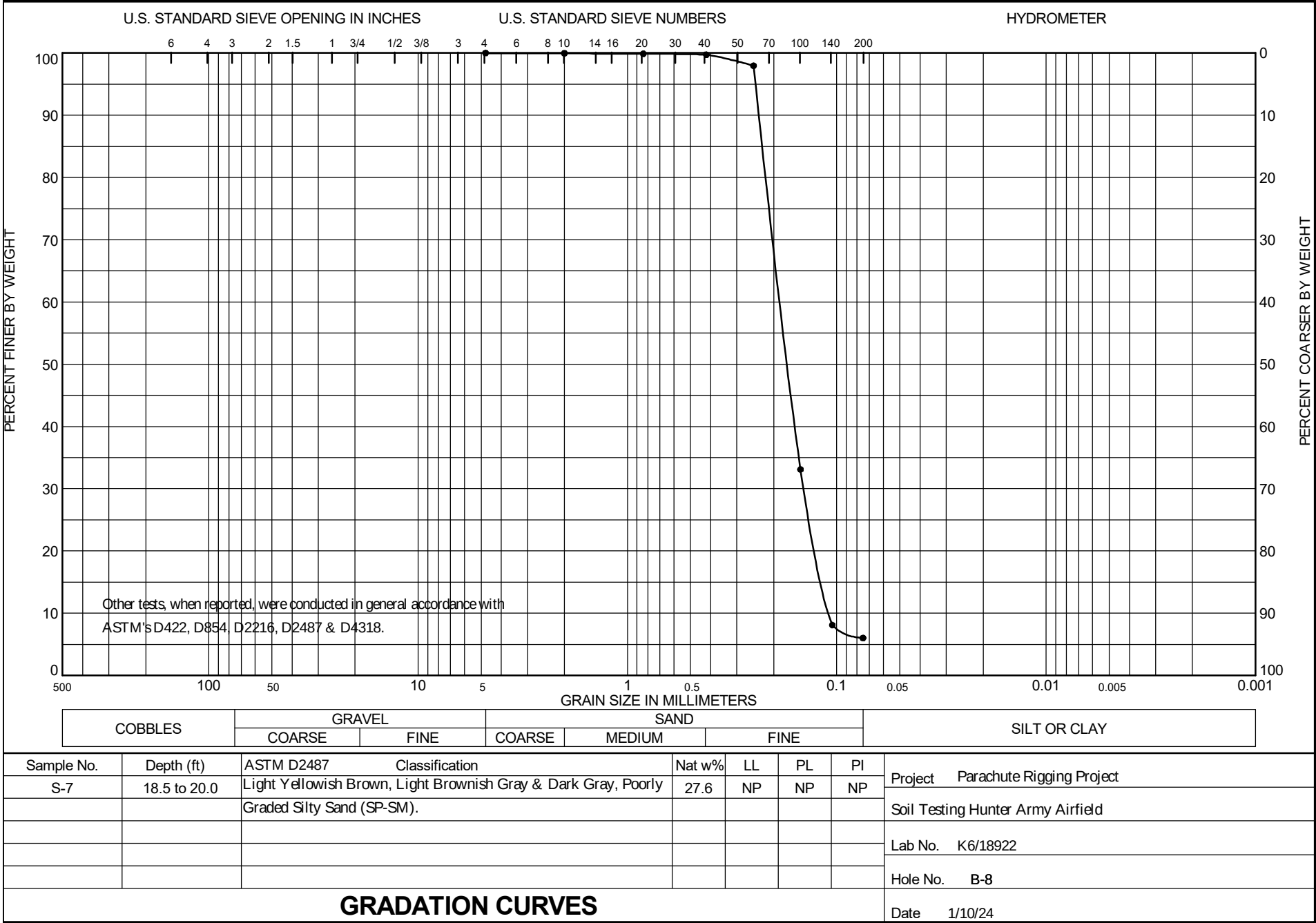


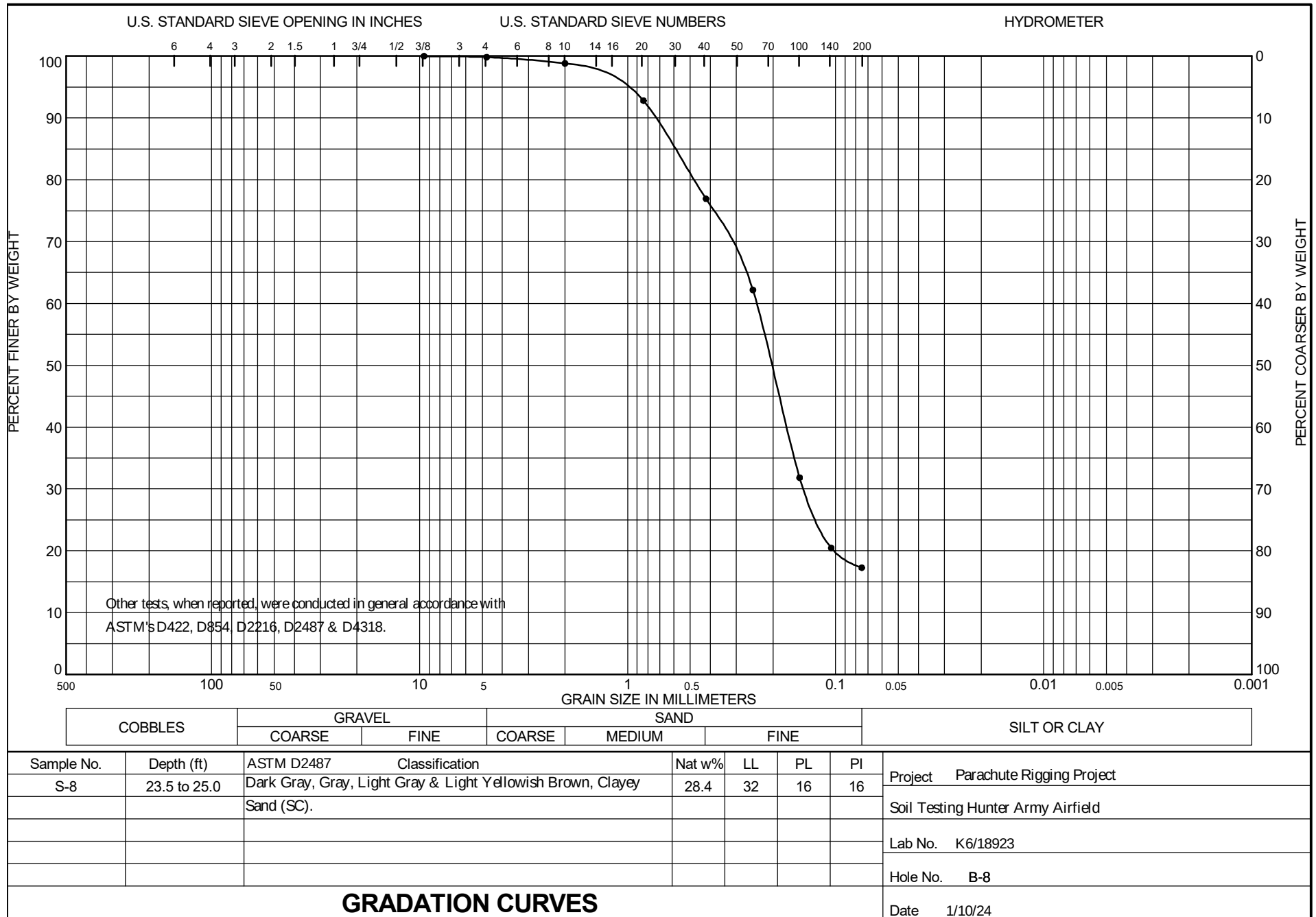
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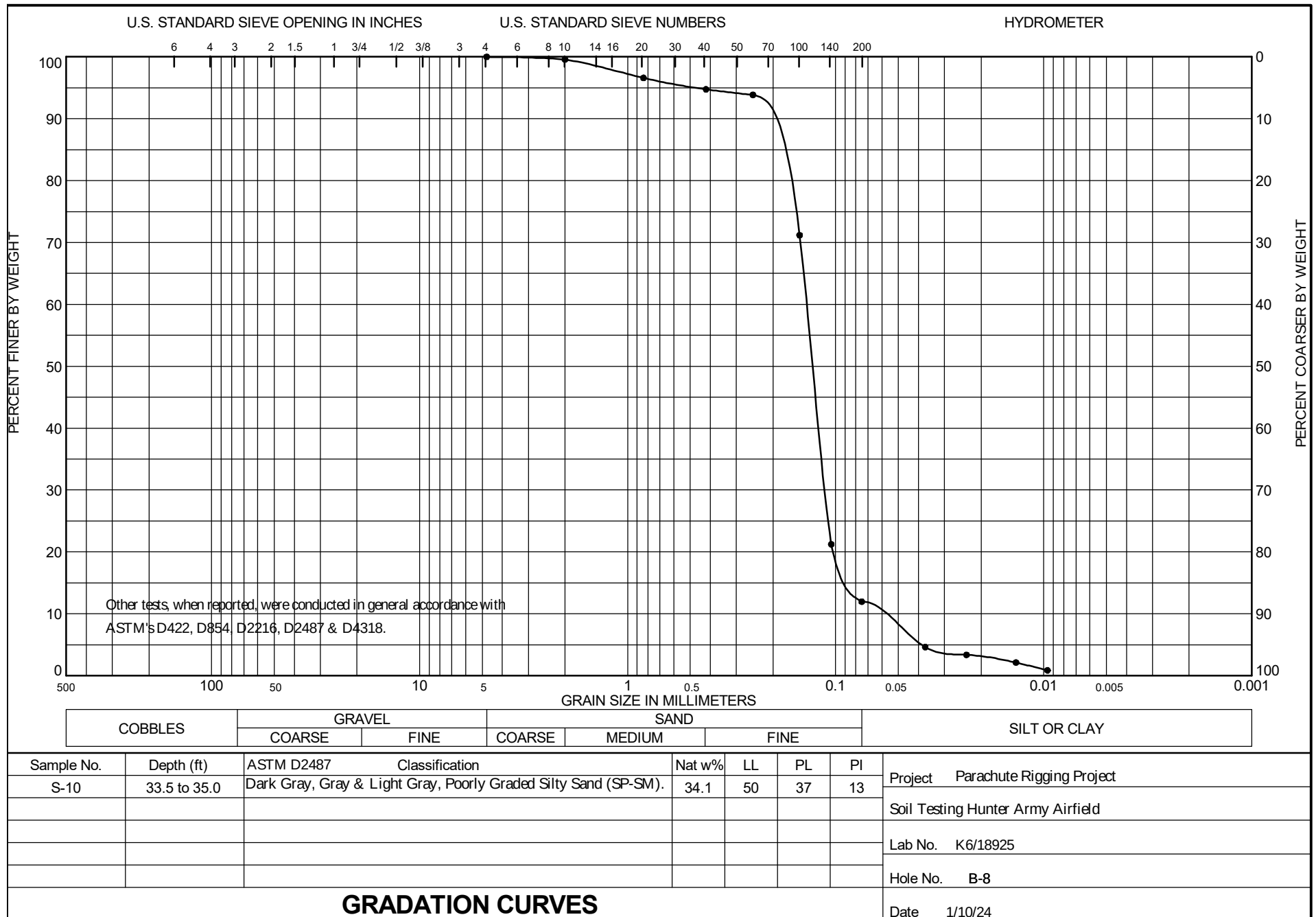




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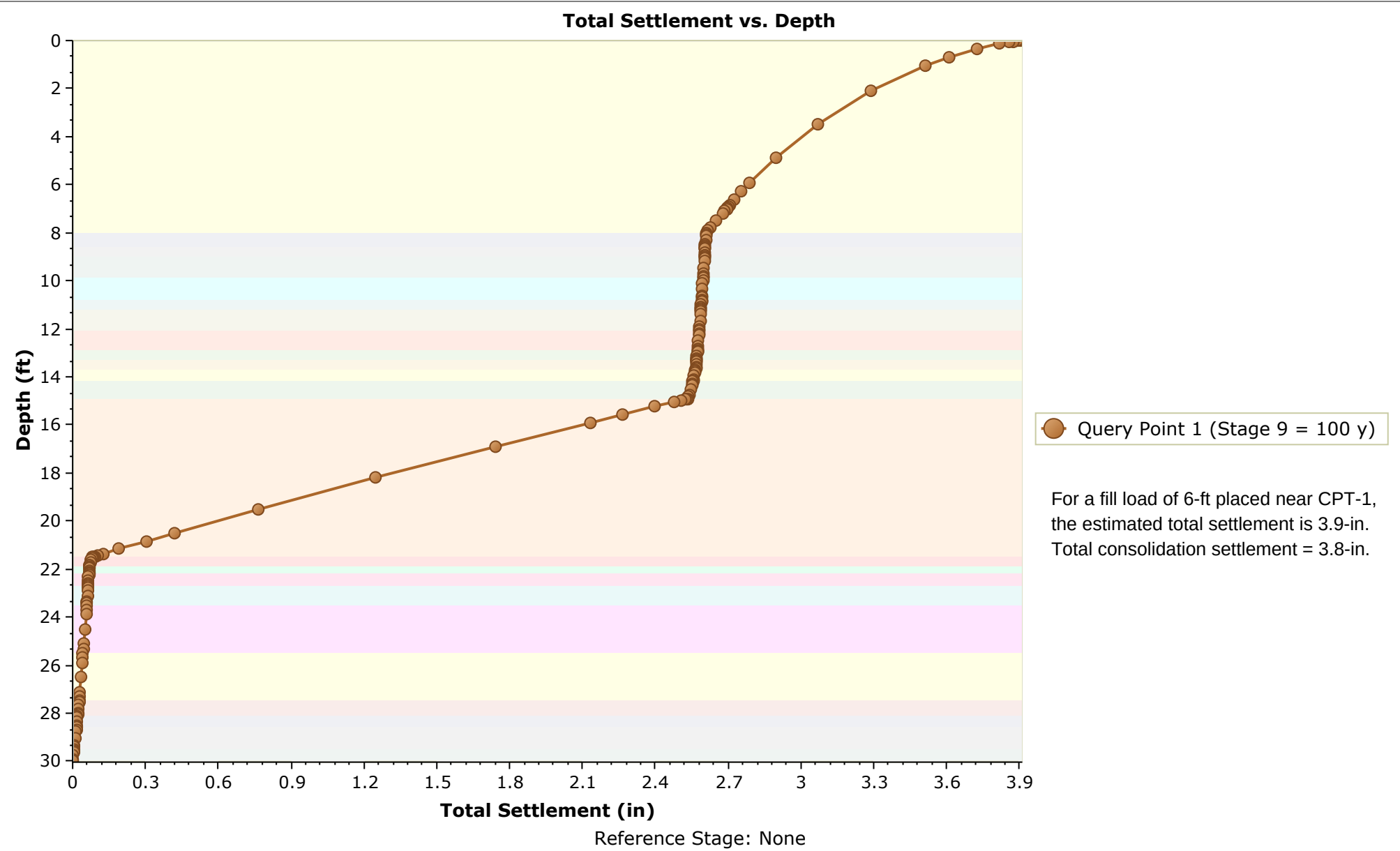
WORK ORDER: 6C176J

REQUISITION: W33SJG23001990



APPENDIX C

TOTAL AND CONSOLIDATION SETTLEMENT SUMMARY

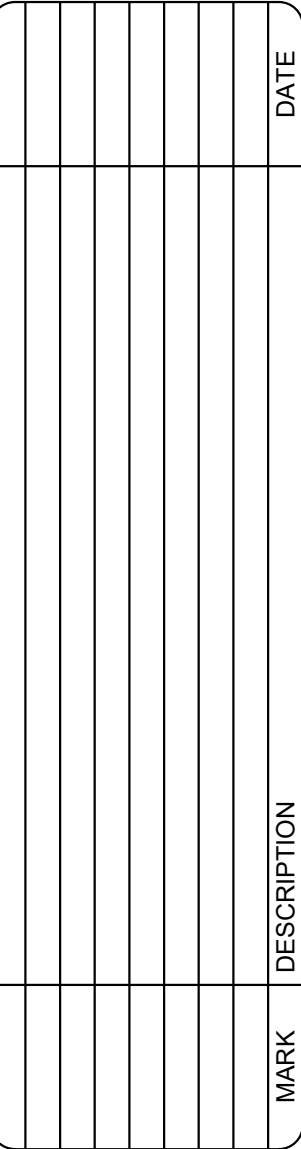
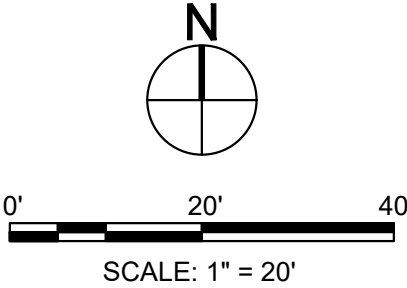


	Project			Hunter Army Airfield, Parachute Rigging Facility	
	Analysis Description			Settlement Evaluation: Constrained Modulus from CPT, Consolidation Parameters from Laboratory	
	Drawn By		N.Bryan		Company
					USACE Savannah District
	Date		1/12/2024, 2:25:40 PM		File Name
				Fill Consolidation_CPT1_6-ft Fill.s3z	



A SECTION
CS506 SETTLEMENT PLATE

LOCATION OF DIKE EMBANKMENT SETTLEMENT PLATES		
PLATE NO.	STATION	OFFSET
SP-1	905+00	20' LT
SP-2	910+00	20' LT
SP-3	915+00	20' LT



U.S. ARMY CORPS OF ENGINEERS SAVANNAH DISTRICT 100 W. OGLETHORPE AVE. SAVANNAH, GA 31401	ISSUE DATE:	
	DRAWN BY: LUDLEY	
	SOLUTION NO.: W912HN-22-B-5006	
	CHECKED BY: L SCHUMANN	
	CATEGORY CODE	
	ANSI SIZE	CW60522

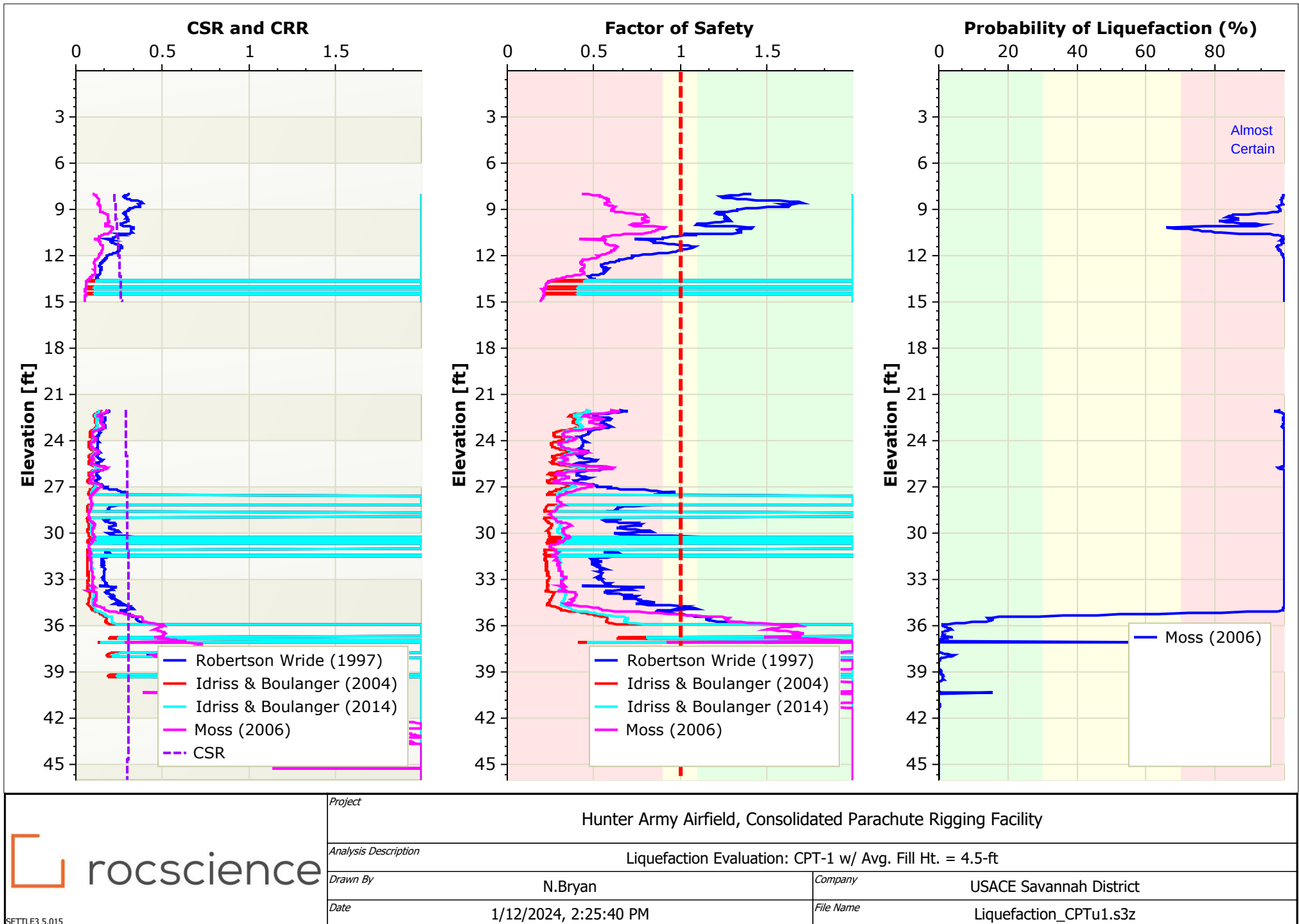
SETTLEMENT PLATE DETAILS

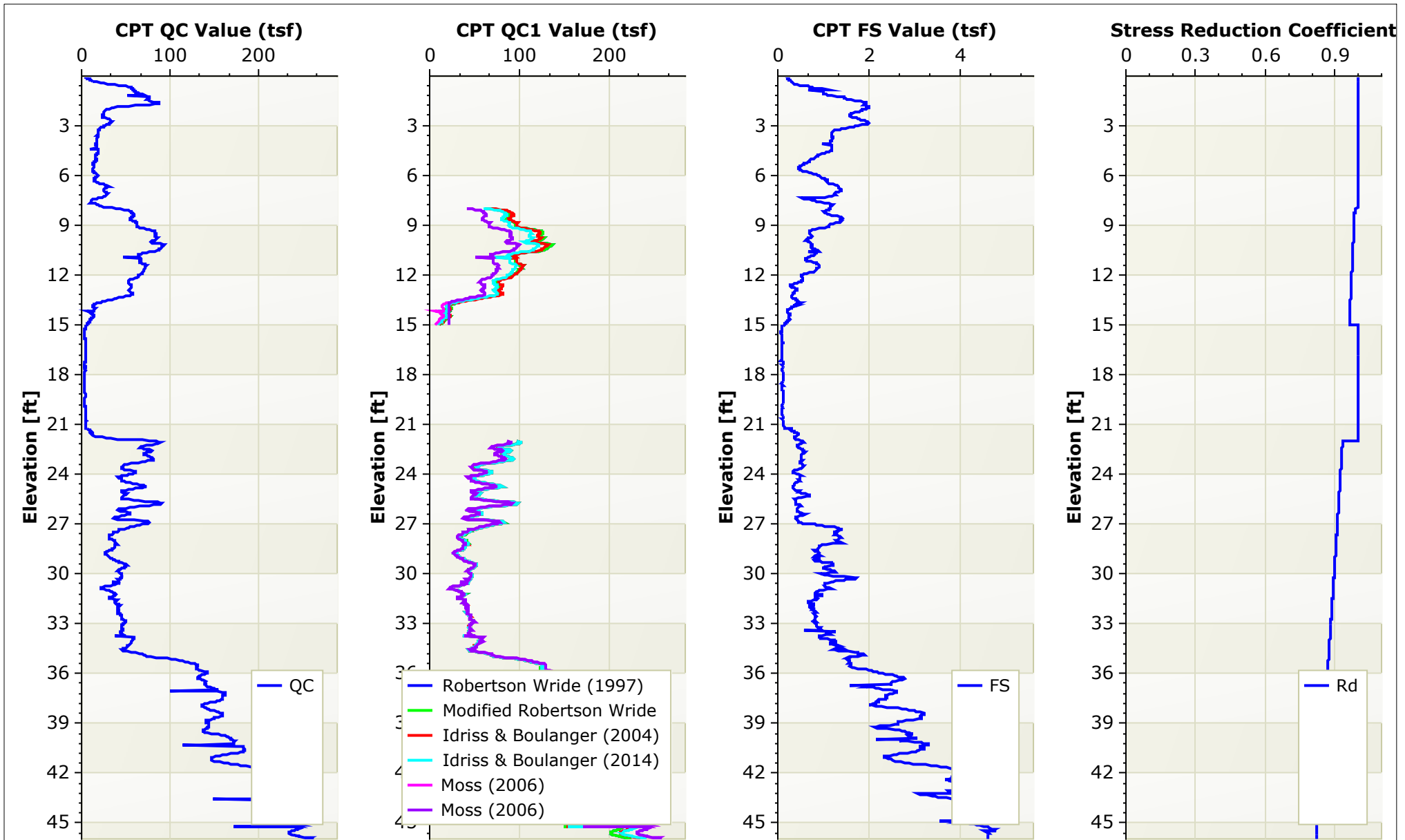
SHEET ID

CS506

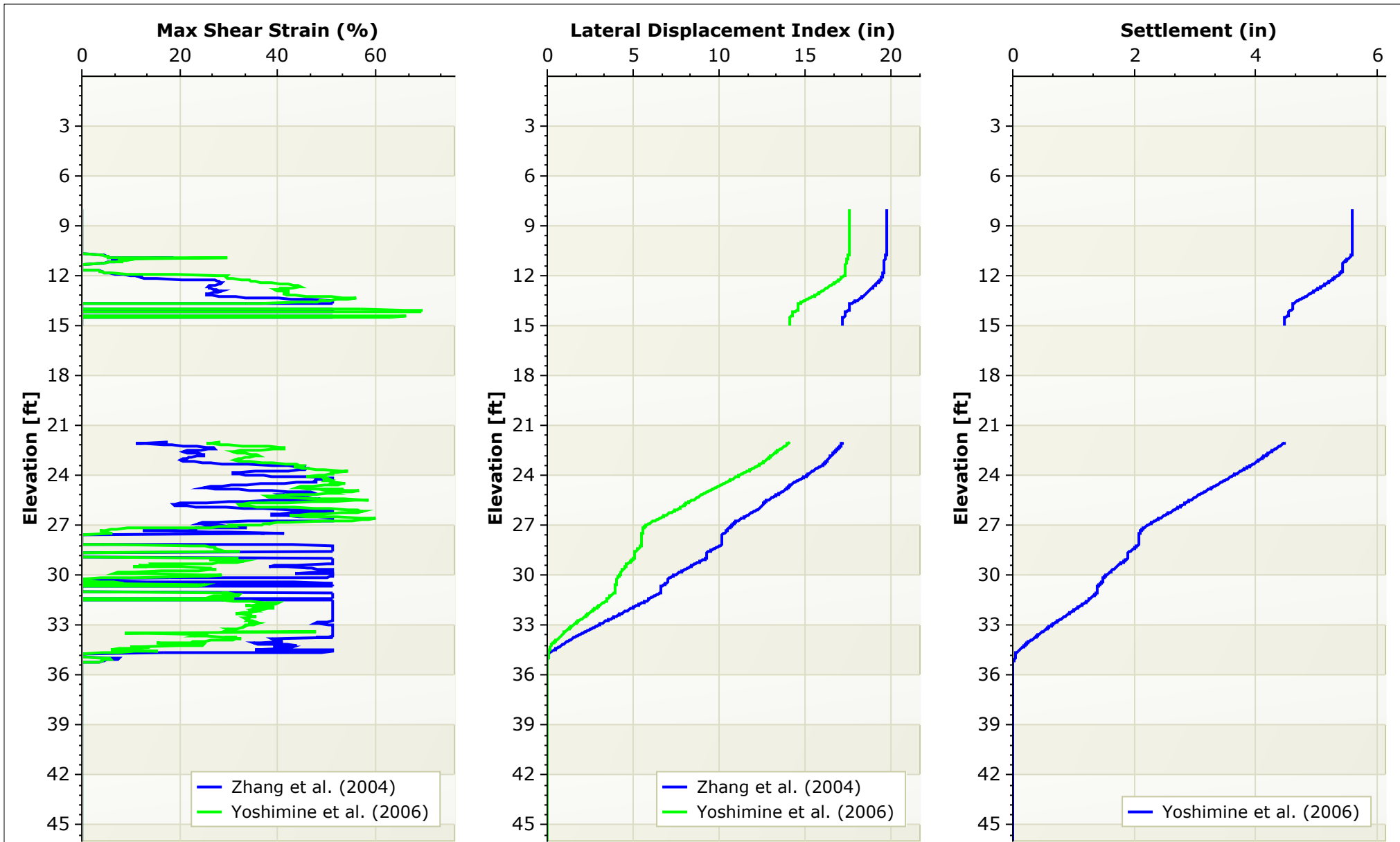
APPENDIX D

LIQUEFACTION EVALUATION

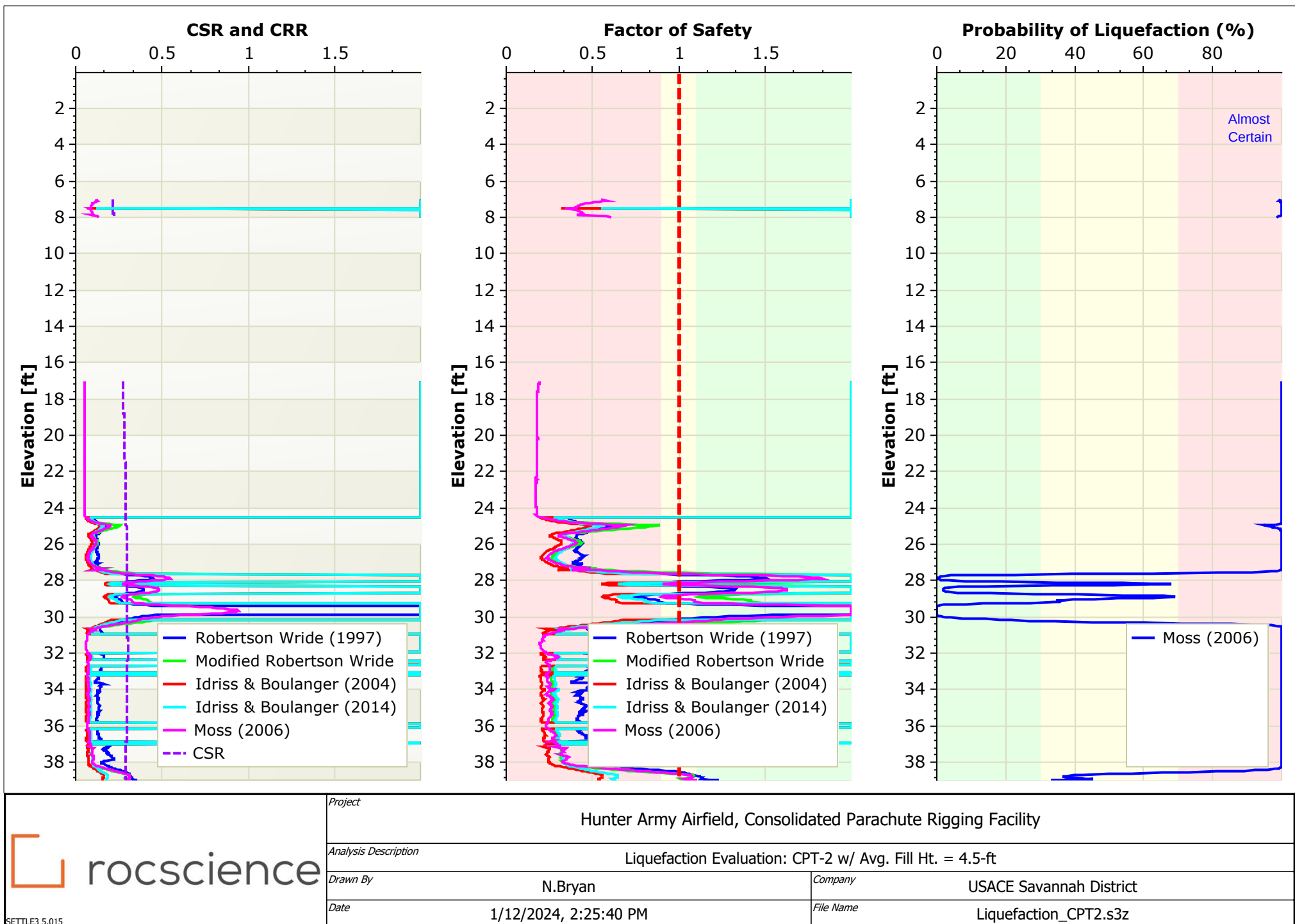


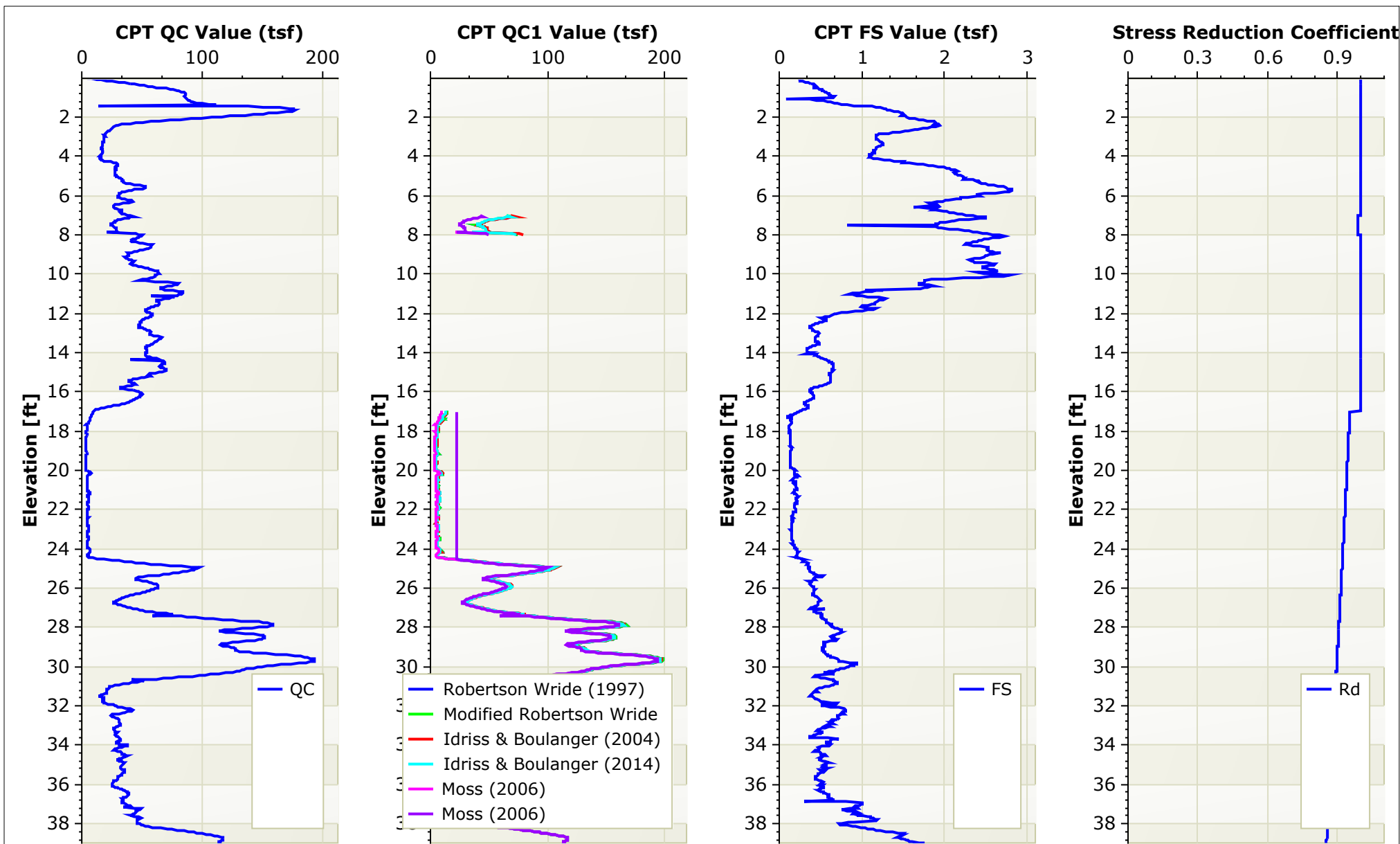


	Project			Hunter Army Airfield, Consolidated Parachute Rigging Facility	
	Analysis Description			Liquefaction Evaluation: CPT-1 w/ Avg. Fill Ht. = 4.5-ft	
	Drawn By		N.Bryan	Company	USACE Savannah District
	Date		1/12/2024, 2:25:40 PM	File Name	Liquefaction_CPTu1.s3z

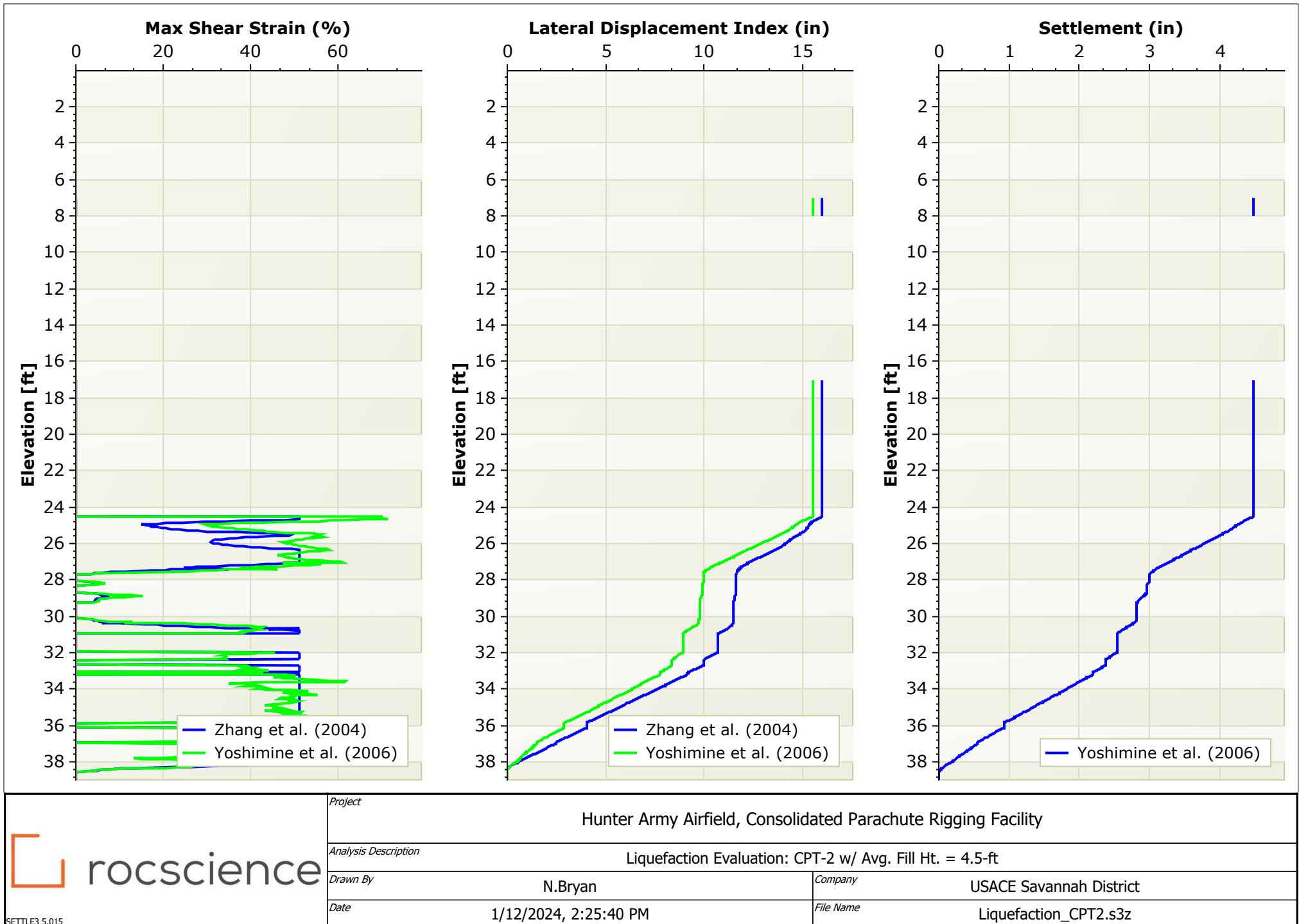


	Project			Hunter Army Airfield, Consolidated Parachute Rigging Facility	
	Analysis Description			Liquefaction Evaluation: CPT-1 w/ Avg. Fill Ht. = 4.5-ft	
	Drawn By		N.Bryan	Company	USACE Savannah District
	Date		1/12/2024, 2:25:40 PM	File Name	Liquefaction_CPTu1.s3z





	Project			Hunter Army Airfield, Consolidated Parachute Rigging Facility	
	Analysis Description			Liquefaction Evaluation: CPT-2 w/ Avg. Fill Ht. = 4.5-ft	
	Drawn By		N.Bryan	Company	USACE Savannah District
	Date		1/12/2024, 2:25:40 PM	File Name	Liquefaction_CPT2.s3z



CPT-based liquefaction triggering analysis for a single sounding

CPT-B7

Input parameters:

PGA = MCE ₀ =	0.156
F _{PGA}	2.122
PGA ₀ = F _{PGA} * PGA	0.331
Earthquake magnitude, M _w =	7.3
Water table depth (ft) =	7
Average unit wt. above water table (lb/ft ³) =	115
Average unit wt. below water table (lb/ft ³) =	115
Target FOS	1.35

Computed constants:

Magnitude scaling factor, MSF = 1.07

Note 1

CSR - Cyclic Stress Ratio - Earthquake Load

CRR - Cyclic Resistance Ratio

Definition of Coefficients:

Tip q_{tip} = resistance at the tip of the cone normalized to atmospheric pressure

FsN = skin resistance along the shaft near the cone normalized to atmospheric pressure

ovc = total vertical stress

Q = vertical effective stress

Q = normalized cone tip resistance

F = friction ratio

Ic = soil behavior type index (see Figure 54 Idriss and Boulanger (2008))

use of the figure and the Ic value yields a description of the soil type (Jefferies and Davies, 1993).

K_u = thin layer factor = 1.0 + 0.25[(H/d_c)/(17-1.77)²]

Interpreted q_c = resulting tip resistance accounting for interface conditions and thin layer corrections.

C_N = overburden correction factor (use is similar to correction of SPT blowcounts to N₁₆₀)

q_{c1N} = corrected tip resistance for overburden pressure and atmospheric pressure

q_{c1Ncs} = corrected tip resistance accounting for fines content

MSF = Magnitude scaling factor = (Mw/7.5)ⁿ, where n=-2.56 and Mw is the earthquake magnitude (Andrus & Stokoe, 1997)

Fines (%) = 1.75I_c^{3.25} - 3.7 for 1.26<Ic<3.5 (Robertson and Wride, 1988)

Note 1. MSF = (Mw/7.5)⁻ⁿ. Use n=-2.56 recommended (Andrus and Stokoe, 1997).

Note 2. Raw, field q_c-values should not be input into an analysis where they are normalized using C_N correction factors based on a new (different) water table depth.

Note 3. Sum only to 20-ft depth.

Note 4. Typically, want FSL > 1.35

(James R. Martin, II, Ph.D. 2002 Personal Communication)

The higher the factor of safety, the more resistant the soil is to liquefaction. However, soil that has a factor of safety greater than 1.0 may still liquefy during an earthquake.

For example, if a lower layer liquefies, then the upward flow of water could induce liquefaction of the layer that has a factor of safety slightly greater than 1.0. In addition, there are many different equations and corrections that are applied to both the CSR induced by the anticipated earthquake and the CRR of the in-situ soil. All the different equations and various corrections, that are applied to both the CSR induced by the anticipated earthquake and the CRR of the in-situ soil, may provide the engineer with a sense of high accuracy, when in fact the entire liquefaction analysis is only a gross approximation (Day 2002 p. 6.17).

Nearly All Case Histories are for Soils < 3,000 yrs old

MEVR (Soil-Aging) Factor

Lateral Displacement Index, LDI

Settlement, S

Note 2

LDI (m) = 1.14 S (m) = 0.188

LDI (ft) = 3.7 S (in) = 7.41

Depth (ft)	Tip q _c (tsf)	F _s (tsf)	Depth (m)	Tip q _{tip} (kPa)	F _{sN} (kPa)	σ _{vc} (kPa)	σ _{vc} ' (kPa)	Q	Friction Ratio, F(%)	I _c	Layer	Flag "Clay" or "Unsaturated"	Est. Fines (%)	Actual Fines %	Interpreted q _{tip} near interfaces	Thin layer factor	Interpreted q _c (thin layer)	C _N	q _{c1N}	q _{c1Ncs}	Stress reduct. coeff, f _σ	CSR	K _u for sand (overburd. corr.)	KDR (age corr.)	CRR for M=7.5 & σ _{vc} '=1atm	CRR	Factor of Safety	Limiting Shear Strain γ _{lim}	Para- meter F _a	Maximum Shear Strain γ _{max}	ΔH _i (m)	ΔLDL _i (m)	Vertical reconsol. Strain, ε _v	ΔS _i (m)	
0.03	3.28	0.16	0.01	3	0.15	0	0	1725	4.80	1.92	Unsaturated		11	65	3	1.70	5	37.3	1.01	0.217	1.10	1.00	0.066	n.a.	n.a.	0.0000	0.000	0.0000	0.015	0.00000	0.00000	0.00000			
0.07	4.41	0.18	0.02	4	0.17	0	0	1160	4.03	1.87	Unsaturated		10	65	4	1.70	7	39.8	1.01	0.217	1.10	1.00	0.068	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.10	5.31	0.20	0.03	5	0.19	1	1	940	3.82	1.87	Unsaturated		10	65	5	1.70	9	41.7	1.01	0.217	1.10	1.00	0.070	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.13	5.92	0.22	0.04	6	0.21	1	1	784	3.66	1.87	Unsaturated		10	65	6	1.70	10	43.1	1.01	0.217	1.10	1.00	0.071	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.16	6.67	0.23	0.05	6	0.22	1	1	706	3.41	1.86	Unsaturated		9	65	6	1.70	11	44.7	1.01	0.217	1.10	1.00	0.073	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.20	7.77	0.23	0.06	7	0.22	1	1	684	3.01	1.81	Unsaturated		8	65	7	1.70	13	47.1	1.01	0.216	1.10	1.00	0.075	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.23	9.08	0.25	0.07	9	0.23	1	1	685	2.70	1.77	Unsaturated		7	65	9	1.70	15	49.9	1.01	0.216	1.10	1.00	0.077	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.26	9.63	0.26	0.08	9	0.24	1	1	638	2.68	1.78	Unsaturated		8	65	9	1.70	16	51.1	1.01	0.216	1.10	1.00	0.079	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.30	10.33	0.27	0.09	10	0.25	2	2	608	2.60	1.77	Unsaturated		8	65	10	1.70	17	52.7	1.01	0.216	1.10	1.00	0.080	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.33	11.85	0.28	0.10	11	0.27	2	2	627	2.37	1.73	Unsaturated		7	65	11	1.70	19	56.0	1.01	0.216	1.10	1.00	0.083	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.36	14.27	0.30	0.11	14	0.28	2	2	686	2.08	1.66	Unsaturated		5	65	14	1.70	23	61.2	1.01	0.216	1.10	1.00	0.089	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.39	17.76	0.31	0.12	17	0.29	2	2	782	1.75	1.57	Unsaturated		4	65	17	1.70	29	68.8	1.01	0.216	1.10	1.00	0.098	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.43	22.04	0.32	0.13	21	0.30	2	2	896	1.46	1.48	Unsaturated		3	65	21	1.70	36	78.1	1.01	0.216	1.10	1.00	0.110	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.46	25.43	0.34	0.14	24	0.32	3	3	962	1.33	1.43	Unsaturated		2	65	24	1.70	41	85.5	1.01	0.216	1.10	1.00	0.120	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.49	29.39	0.35	0.15	28	0.34	3	3	1037	1.21	1.38	Unsaturated		1	65	28	1.70	47	94.1	1.01	0.216	1.10	1.00	0.133	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.53	33.66	0.38	0.16	32	0.36	3	3	1113	1.14	1.35	Unsaturated		1	65	32	1.70	54	103.4	1.01	0.216	1.10	1.00	0.148	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.56	37.62	0.44	0.17	36	0.41	3	3	1170	1.16	1.35	Unsaturated		1	65	36	1.70	61	112.0	1.01	0.216	1.10	1.00	0.164	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.59	42.18	0.48	0.18	40	0.46	3	3	1239	1.15	1.33	Unsaturated		1	65	40	1.70	68	121.9	1.01	0.216	1.10	1.00	0.184	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.62	46.70	0.57	0.19	44	0.54	3	3	1301	1.21	1.35	Unsaturated		1	65	44	1.70	75	131.7	1.01	0.216	1.10	1.00	0.208	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.66	50.33	0.67	0.20	48	0.63	4	4	1332	1.33	1.39	Unsaturated		1	65	48	1.70	81	139.6	1.01	0.216	1.10	1.00	0.231	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.69	53.50	0.71	0.21	51	0.67	4	4	1348	1.33	1.39	Unsaturated		1	65	51	1.70	86	146.5	1.00	0.216	1.10	1.00	0.256	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.72	55.70	0.75	0.22	53	0.71	4	4	1339	1.35	1.39	Unsaturated		1	65	53	1.70	90	151.3	1.00	0.216	1.10	1.00	0.277	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.76	56.63	0.80	0.23	54	0.75	4	4	1302	1.41	1.41	Unsaturated		2	65	54	1.70	91	153.3	1.00	0.216	1.10	1.00	0.287	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.79	57.43	0.86	0.24	54	0.81	4	4	1267	1.49	1.44	Unsaturated		2	65	54	1.70	93	155.1	1.00	0.216	1.10	1.00	0.297	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.82	58.07	0.97	0.25	55	0.92	5	5	1229	1.67	1.49	Unsaturated		3	65	55	1.70	94	156.5	1.00	0.216	1.10	1.00	0.304	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.85	58.59	1.12	0.26	56	1.06	5	5	1192	1.91	1.55	Unsaturated		4	65	56	1.70	94	157.6	1.00	0.216	1.10	1.00	0.311	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.89	59.39	0.67	0.27	56	0.64	5	5	1164	1.14	1.34	Unsaturated		1	65	56	1.70	96	159.3	1.00	0.216	1.10	1.00	0.322	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.92	60.06	0.93	0.28	57	0.88	5	5	1134	1.55	1.47	Unsaturated		2	65	57	1.70	97	160.8	1.00	0.216	1.10	1.00	0.331	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.95	60.34	0.97	0.29	57	0.92	5	5	1101	1.62	1.49	Unsaturated		3	65	57	1.70	97	161.4	1.00	0.216	1.10	1.00	0.336	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
0.98	60.88	1.00	0.30	58	0.95	5	5	1074	1.64	1.50	Unsaturated		3	65	58	1.70	98	162.6	1.00	0.216	1.10	1.00	0.344	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.02	61.66	1.00	0.31	58	0.95	6	6	1052	1.63	1.50	Unsaturated		3	65	58	1.70	99	164.3	1.00	0.216	1.10	1.00	0.357	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.05	63.66	1.00	0.32	60	0.94	6	6	1052	1.57	1.48	Unsaturated		3	65	60	1.70	103	168.6	1.00	0.216	1.10	1.00	0.394	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.08	65.67	1.00	0.33	62	0.94	6	6	1053	1.52	1.47	Unsaturated		2	65	62	1.70	106	173.0	1.00	0.216	1.10	1.00	0.440	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.12	69.30	1.01	0.34	64	0.96	6	6	1056	1.50	1.47	Unsaturated		2	65	64	1.70	109	177.6	1.00	0.216	1.10	1.00	0.500	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.15	67.84	1.05	0.35	66	1.00	6	6	1048	1.52	1.47	Unsaturated		2	65	66	1.70	112	181.0	1.00	0.216	1.10	1.00	0.552	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.19	71.72	1.04	0.36	68	1.04	7	7	1064	1.54	1.48	Unsaturated		2	65	68	1.70	115	182.2	1.00	0.216	1.10	1.00	0.604	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.21	75.87	1.09	0.37	68	1.13	7	7	727	2.34	1.70	Unsaturated		4	65	68	1.70	82	140.8	1.00	0.216	1.10	1.00	0.235	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.25	76.40	1.31	0.38	72	1.25	7	7	1064	1.72	1.52	Unsaturated		3	65	72	1.70	123	196.4	1.00	0.216	1.10	1.00	0.968	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.28	77.22	1.41	0.39	73	1.33	7	7	1047	1.83	1.55	Unsaturated		4	65	73	1.70	124	198.1	1.00	0.216	1.10	1.00	1.045	n.a.	n.a.	0.0000	0.000	0.0000	0.010	0.00000	0.00000	0.00000			
1.31	77.01	1.45	0.40	73	1.37	7	7	1019	1.88																										

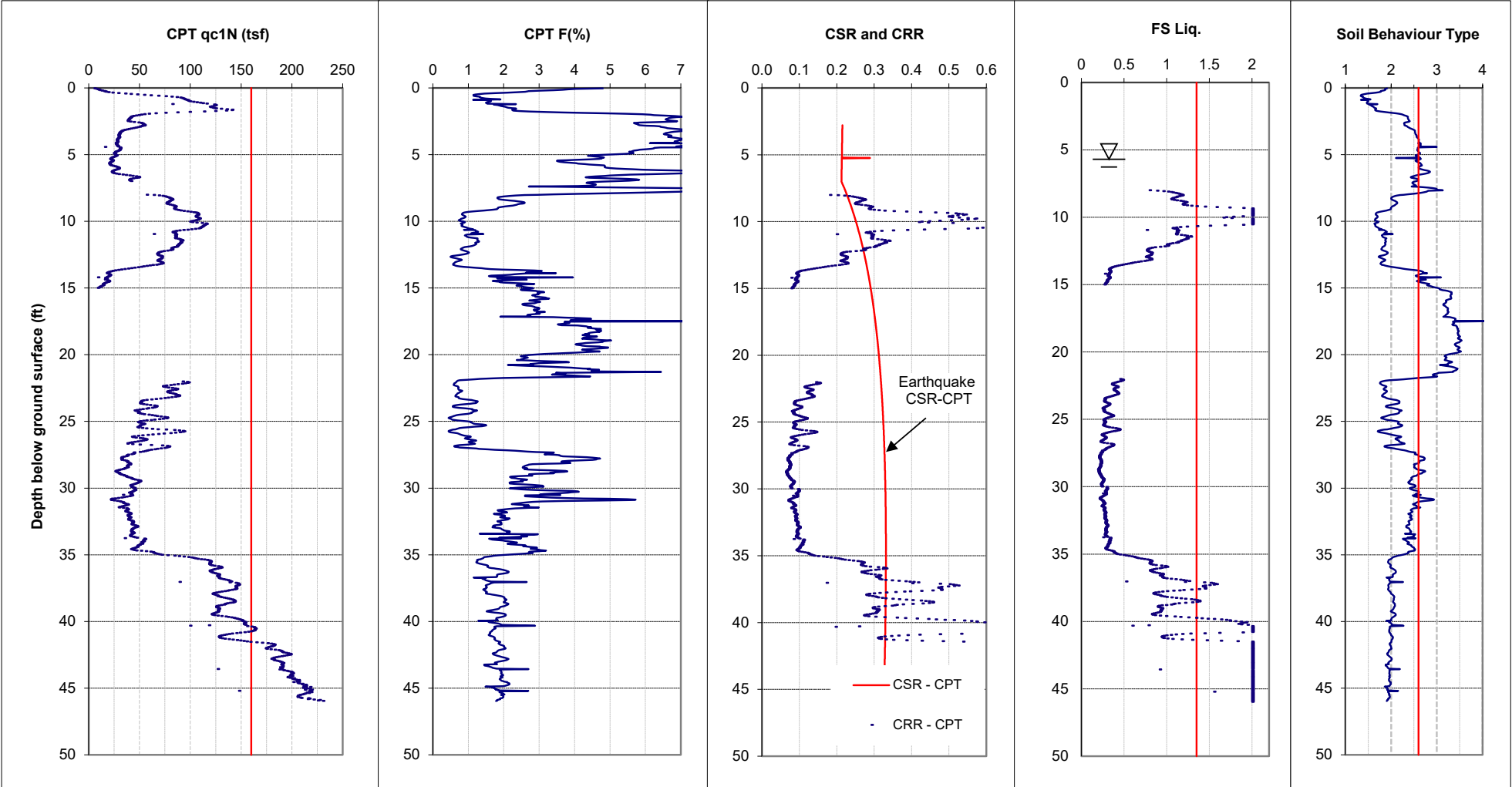


FIGURE 3 - CPT LIQUEFACTION TRIGGERING ANALYSIS

- Notes:**
1. Assumes groundwater at approx. 7-ft.
 2. CRR not corrected for soil-aging effects (Andrus & Hayati, 2009).

Zone	Soil Behaviour Type	I _c
1	Sensitive, fine grained	N/A
2	Organic soils – peats	> 3.6
3	Clays – silty clay to clay	2.95 - 3.6
4	Silt mixtures – clayey silt to silty clay	2.60 – 2.95
5	Sand mixtures – silty sand to sandy silt	2.05 – 2.6
6	Sands – clean sand to silty sand	1.31 – 2.05
7	Gravelly sand to dense sand	< 1.31
8	Very stiff sand to clayey sand*	N/A
9	Very stiff, fine grained*	N/A

* Heavily overconsolidated or cemented

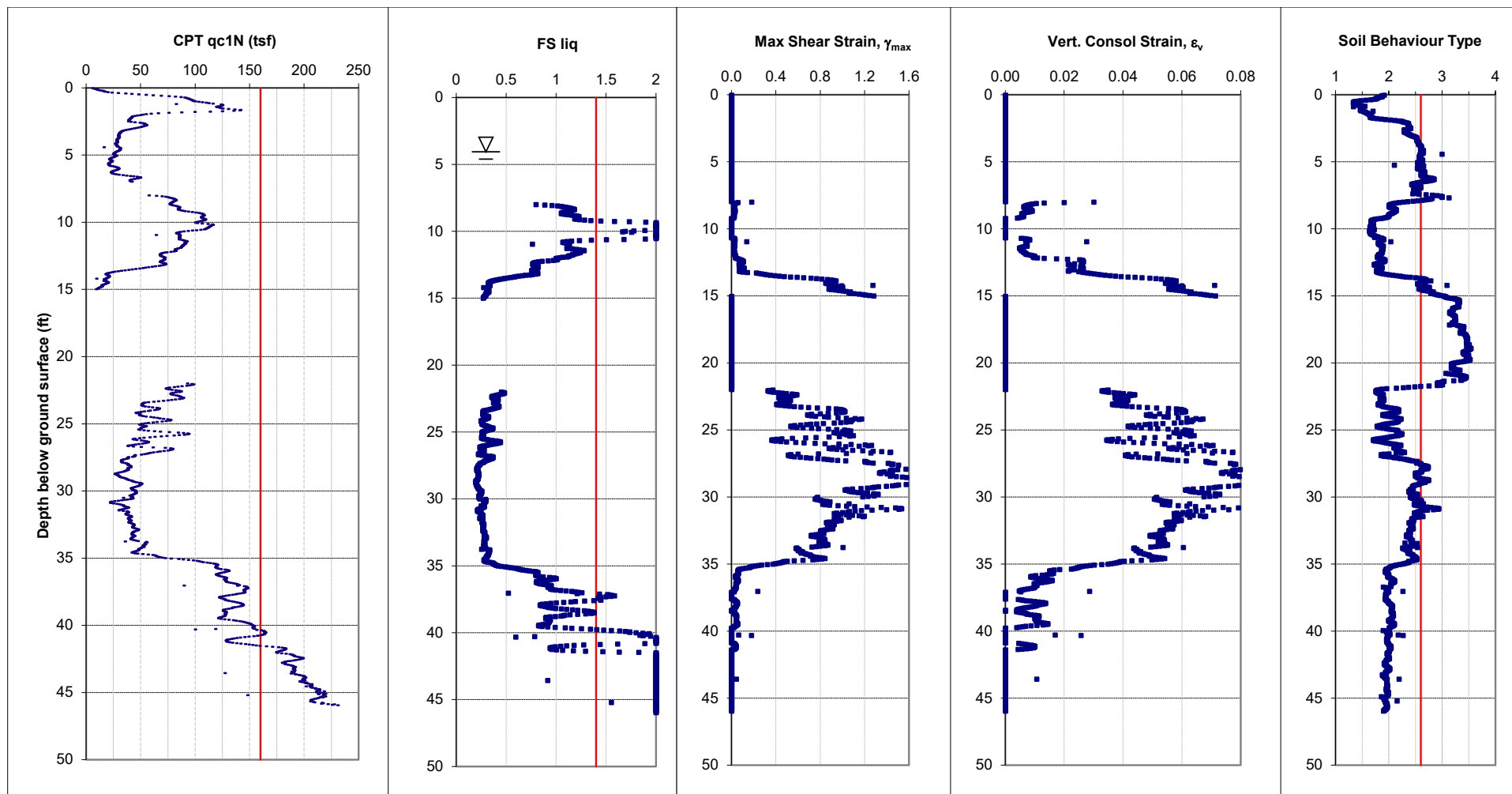


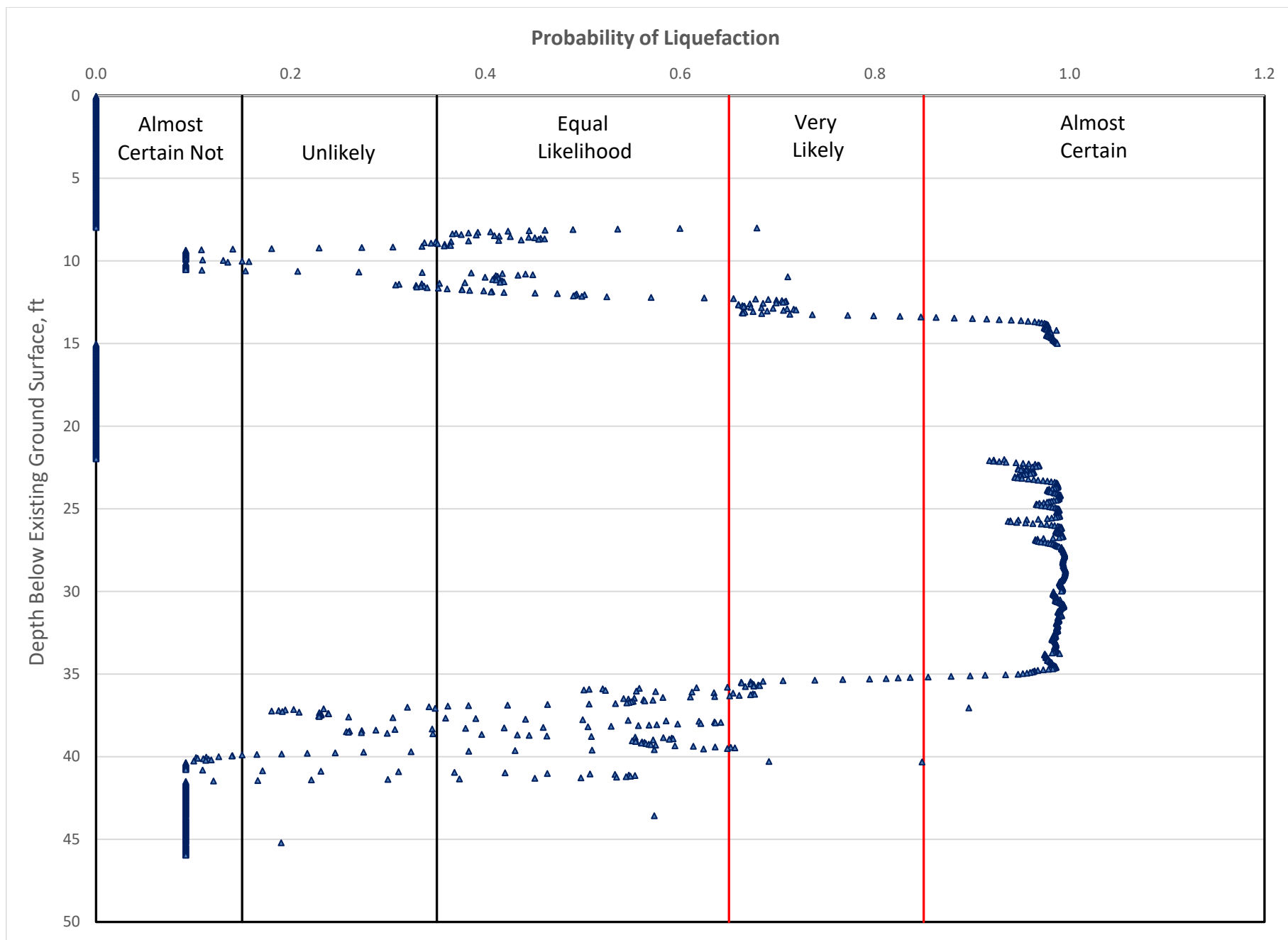
FIGURE 4 - LDI and 1-D Reconsolidation Settlement (Single CPT Sounding)

Notes: 1. Assumes groundwater at approx. 4-ft.

Table 1 - Liquefaction Evaluation Summary (CPTu 2a)

Seismic Hazard	Liquefiable Layers (ft)	LPI	Volumetric Compression (in.)	Lateral Displacement, ft
2%/50 yr (MCE)	40 to 40	0	5.5	7.3
10%/50 yr	48 to 50	0	< 1 inch	0.1

Note: Boring advanced approximately 250-ft from edge of free face; slope height = 35-ft.





Prepared By: N. Bryan Date: 08 Feb 2024
 Checked By: Date:
 Status: FINAL

Ref: International Code Council, 2012 *International Building Code*.
ASCE 7-16, *Minimum Design Loads for Buildings and Other Structures*. so

- ☐ 1) Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils
 - ☐ 2) Peats and/or highly organic clays ($H > 10$ feet)
 - ☐ 3) Very high plasticity clays ($H > 25$ feet with Plasticity Index, $PI > 75$)
 - ☐ 4) Very thick soft/medium stiff clays ($H > 120$ feet)
- Proceed to Step 2

- ☐ 1) Undrained shear strength, $s_u < 500$ psf
- ☒ 2) Moisture content, $w \geq 40$ percent
- ☒ 3) Plasticity Index, $PI > 20$
- Proceed to Step 3

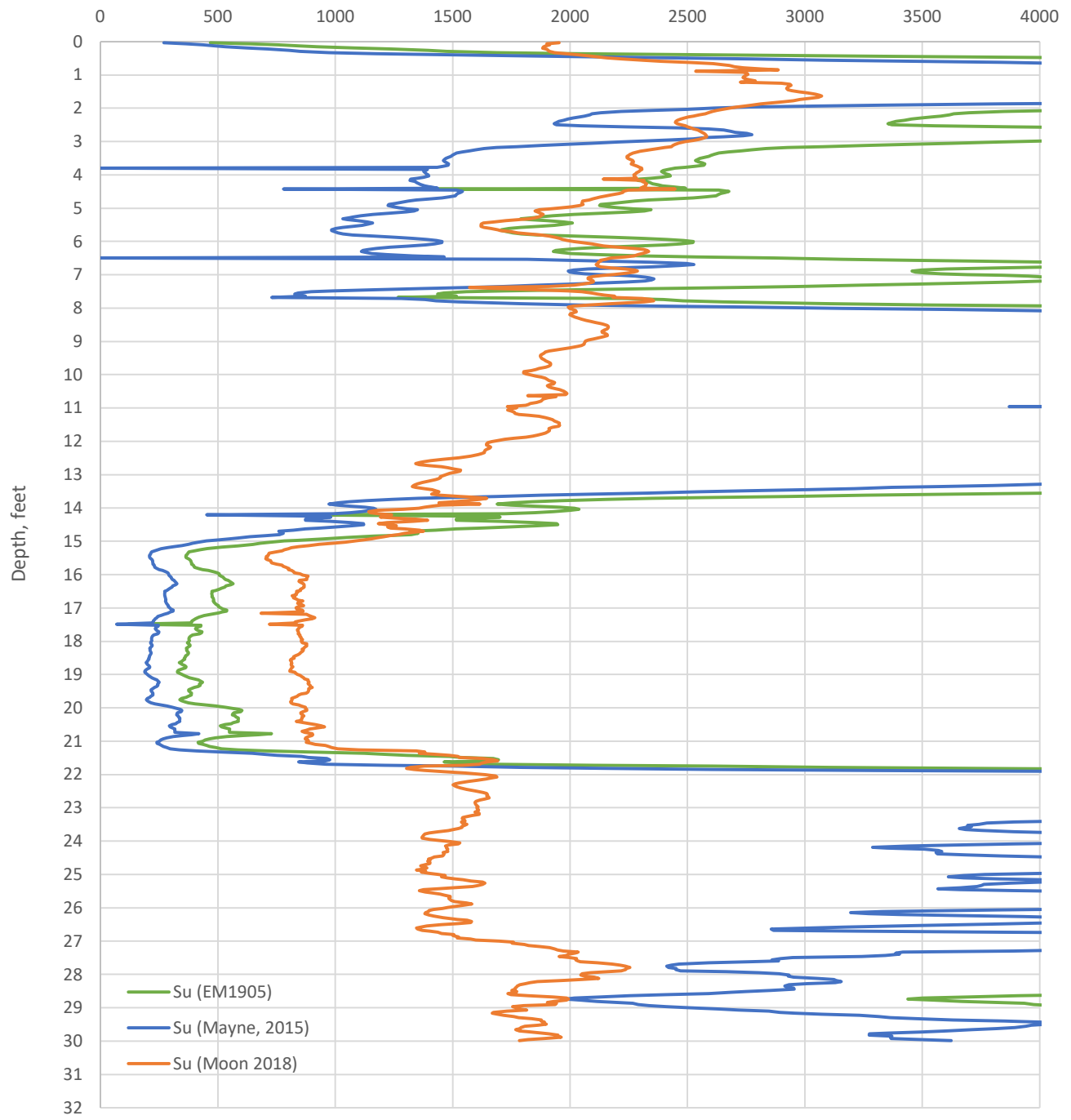
Stratigraphy			
z _{top} (feet)	z _{bot} (feet)	Soil Type	d (feet)
0.0	3.6	CH	3.6
3.6	6.8	CH	3.2
6.8	10.1	CH to SC	3.3
10.1	13.3	SC	3.2
13.3	16.6	SC to CL	3.3
16.6	19.9	CL	3.3
19.9	23.1	CL	3.2
23.1	26.4	SP	3.3
26.4	29.6	SP	3.2
29.6	32.9	SP-SC	3.3
32.9	36.2	SP-SC	3.3
36.2	39.4	SP-SC	3.2
39.4	42.7	SP-SC	3.3
42.7	45.1	SP-SC	2.4
45.1	50.0	SM	4.9
50.0	100.0	No Info	50
Layer-Weighted Average			100

1) v_s Method	
v_s (ft/s)	d/v_s (sec)
874	0.004
1,118	0.003
1,078	0.003
1,114	0.003
1,176	0.003
1,107	0.003
1,110	0.003
956	0.003
717	0.004
667	0.005
665	0.005
615	0.005
797	0.004
807	0.003
937	0.005
900	0.056
889	D

[illegible][illegible]

Notes: Use SPT N-values as directly measured in the field without corrections; use N = 100 bpf for rock layers; and s_u shall not be taken greater than 5,000 psf. Site Classes A and B shall not be used when there is more than 10 feet of soil between the rock surface and the bottom of the spread footing or mat foundation. Site Class A shall be supported by either shear wave velocity measurements on site or on profiles of the same rock type in the same formation with an equal or greater degree of weathering and fracturing. Site Class B shall be based on the shear wave velocity for rock. For competent rock with moderate fracturing and weathering, this shear wave velocity can be estimated. For more highly fractured and weathered rock, the shear wave velocity shall be directly measured, or the site shall be assigned to Site Class C.

Boring CPT-1: Undrained Shear Strength, psf





**US Army Corps
of Engineers**
Louisville District

Project: Consolidated Parachute Rigging Facility
Subject: Seismic Design Category
District: SAS
Location: Hunter AAF, Georgia

Prepared By: N. Bryan Date: 08 Feb 2024
Checked By: Date: 00 Jan 1900
Status: FINAL

Seismic Design Category

Ref: International Code Council, 2012 *International Building Code*.
ASCE 7-16, *Minimum Design Loads for Buildings and Other Structures*.
UFC 3-310-04, *Seismic Design of Buildings*.

Mapped Acceleration Parameters

Latitude 32.006216 °
Longitude -81.171872 °
Event 2% PE in 50 yr

Site Classification for Seismic Design

Site Class D

Rock Conditions

Site Location CEUS Central and Eastern United States
Site Rock Type Hard Rock

Mapped MCE Spectral Response Acceleration Parameter at 0.2-second Period, S_s (0.2 sec SA) 0.287 g
Mapped MCE Spectral Response Acceleration Parameter at 1.0-second Period, S_1 (1.0 sec SA) 0.107 g

Site Coefficients

Short-Period Site Coefficient, F_a 1.570
Long-Period Site Coefficient, F_v 2.386

Site Class	S_s (g)					
	≤ 0.25	0.5	0.75	1.0	1.25	≥ 1.5
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3			

Site Class	S_1 (g)					
	≤ 0.1	0.2	0.3	0.4	0.5	≥ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2	2.0	1.9	1.8	1.7
E	4.2					

Adjusted Acceleration Parameters

$S_{MS} = F_a \cdot S_s$ 0.451 g
 $S_{M1} = F_v \cdot S_1$ 0.255 g

Design Acceleration Parameters

$S_{DS} = (2/3) \cdot S_{MS}$ 0.300 g
 $S_{D1} = (2/3) \cdot S_{M1}$ 0.170 g

Risk Category

Risk Category I&II
Importance Factor 1.0

Seismic Design Category

Value of S_{DS}	Risk Category		
	I & II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS} < 0.75g$	D	D	D
$S_{DS} \geq 0.75g$	E	E	F

Value of S_{D1}	Risk Category		
	I & II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \leq S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1} < 0.75g$	D	D	D
$S_{D1} \geq 0.75g$	E	E	F

Seismic Design Category based on S_{DS} B
Seismic Design Category based on S_{D1} C
Most Severe Seismic Design Category C



**US Army Corps
of Engineers**
Louisville District

Project: Consolidated Parachute Rigging Facility
 Subject: Design Response Spectrum
 District: SAS
 Location: Hunter AAF, Georgia

Prepared By: N. Bryan Date: 08 Feb 2024
 Checked By: Date: 00 Jan 1900
 Status: FINAL

Design Response Spectrum

Ref: International Code Council, *2012 International Building Code*.
 ASCE 7-16, *Minimum Design Loads for Buildings and Other Structures*.

Design Acceleration Parameters

$$S_{DS} = (2/3) \cdot S_{MS} = (2/3) \cdot (F_a \cdot S_s) \quad \underline{\underline{0.300 \text{ g}}}$$

$$S_{D1} = (2/3) \cdot S_{M1} = (2/3) \cdot (F_v \cdot S_1) \quad \underline{\underline{0.170 \text{ g}}}$$

Long-Period Transition Period

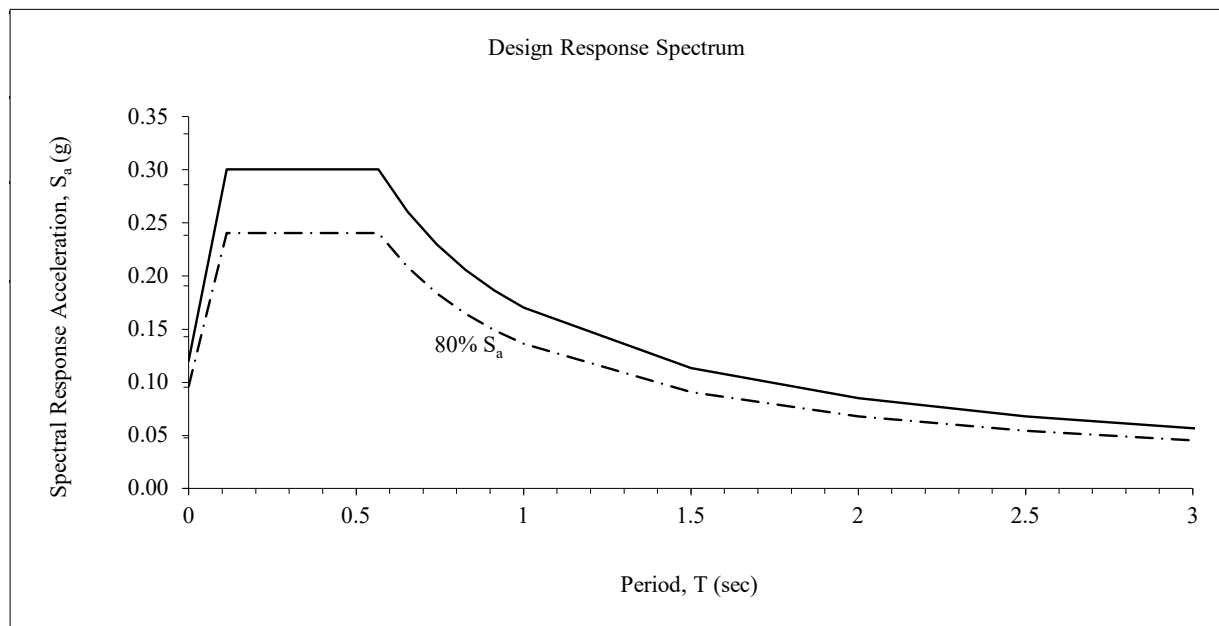
$$T_L \text{ (from Figure 22-14 ASCE 7-16)} \quad \underline{\underline{8 \text{ sec}}}$$

Design Response Spectrum

T (sec)	0.000	0.031	T_0 0.113	T_s 0.566	0.653	0.740	0.827	0.913	T_1 1.000	1.500	2.000	2.500	3.000	4.250	5.500	6.750	T_L 8.000	8.500	9.000	9.500
S_a (g)	0.120	0.170	0.300	0.300	0.261	0.230	0.206	0.186	0.170	0.113	0.085	0.068	0.057	0.040	0.031	0.025	0.021	0.019	0.017	0.015
80% of S_a (g)	0.096	0.136	0.240	0.240	0.208	0.184	0.165	0.149	0.136	0.091	0.068	0.054	0.045	0.032	0.025	0.020	0.017	0.015	0.013	0.012
		S_{D1}	S_{DS}	S_{DS}																

For $T \leq T_0$ $S_a = 0.6 \cdot (S_{DS}/T_0) \cdot T + 0.4 \cdot S_{DS}$
 For $T_0 \leq T \leq T_s$ $S_a = S_{DS}$
 For $T_s < T \leq T_L$ $S_a = S_{D1}/T$
 For $T > T_L$ $S_a = (S_{D1} \cdot T_L)/T^2$

where $T_0 = 0.2 \cdot (S_{D1}/S_{DS})$
 and
 $T_s = S_{D1}/S_{DS}$





Project: Consolidated Parachute Rigging Facility
Subject: Fundamental Period of Building
District: SAS
Location: Hunter AAF, Georgia

Prepared By: N. Bryan Date: 08 Feb 2024
Checked By: Date: 00 Jan 1900
Status: FINAL

Fundamental Period of Building

Ref: International Code Council, 2012 International Building Code.
ASCE 7-16, Minimum Design Loads for Buildings and Other Structures.

Design Spectral Response Accelerations

$S_{DS} = (2/3) \cdot S_{MS}$ 0.300 g
 $S_{D1} = (2/3) \cdot S_{M1}$ 0.170 g

Upper Limit on Calculated Fundamental Period

Value of S_{D1}	0.1	0.15	0.2	0.3	0.4
Coefficient, C_u	1.7	1.6	1.5	1.4	1.4

Coefficient, C_u 1.560
 $T \leq T_u \cdot C_u$ 0.404 sec

Approximate Fundamental Period

Structure Type (Mark one only.)

- ☐ Moment resisting frame systems of steel in which the frames resist 100 percent of the required seismic force and are not enclosed or adjoined by more rigid components that will prevent the frames from deflecting when subjected to seismic forces.
- ☐ Moment resisting frame systems of reinforced concrete in which the frames resist 100 percent of the required seismic force and are not enclosed or adjoined by more rigid components that will prevent the frames from deflecting when subjected to seismic forces.
- ☐ Eccentrically braced steel frames and buckling restrained braced frames.
- ☒ All other structural systems.

C_r	α
0.028	0.8
0.016	0.9
0.03	0.75
0.02	0.75

Height above the base to the highest level of the building, h_n

40 feet

Approximate fundamental period, $T_a = C_r \cdot h_n^x$

0.318 sec

Alternative formula for concrete and steel moment resisting frame structures not exceeding 12 stories in height and having a minimum story height of not less than 10 feet.

Number of stories, N

2 stories

Approximate fundamental period, $T_a = 0.1 \cdot N$

0.200 sec

Use approximate fundamental period, T_a

0.259 sec

Long Period Exclusion (ASCE 11.6)

Ignore S_{D1} per ASCE 11.6, use only S_{DS} if all criteria are met

Item 1:

Is $S_{D1} < 0.75$? Yes
 $h_n = 30$ ft Structural height, 11.2
 $T_a = C_r \cdot h_{n,x} = 0.256$ s ASCE 7-10, 12.8.2.1
 $T_s = S_{D1}/S_{DS} = 0.566$ s ASCE 7-10, 11.4.5
Is $T_a < 0.8 T_s$? Yes

Table 12.8-2	
$C_t =$	0.02
$\alpha =$	0.75

Item 2:

$C_d = 2.25$
 $R = 3.5$
 $C_u = 1.6$
 $T_{upper\ limit} = 0.41$
Assume Ordinary Reinforced Masonry Shear Walls
Deflection Amplification Factor, ASCE 7-10, Table 12.2-1
Response Modification Factor, ASCE 7-10, Table 12.2-1
Coef. for upper limit, ASCE 7-10 Table 12.8-1
ASCE 12.8.2

In each of the two orthogonal directions, the fundamental period used to calculate story drift is less than T_s ? Yes Use $T_{upper\ limit}$

Item 3:

$T_L = 8$ s Long period transition period, ASCE 7-10, 11.4.5
 $C_S = 0.086$ ASCE 7-10, Equation 12.8-2
 $C_{S, \max} = 0.119$ ASCE 7-10, Equation 12.8-3
 $C_{S, \min} = 0.013$ ASCE 7-10, Equation 12.8-5

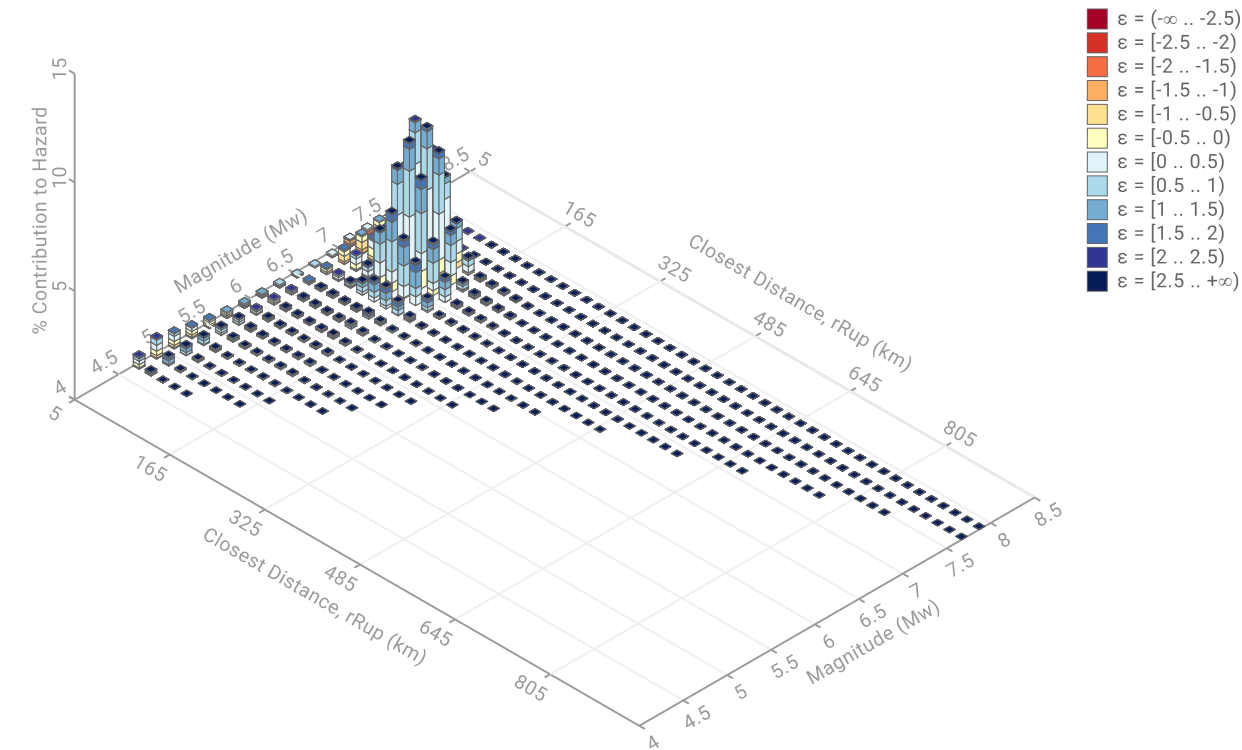
Is equation 12.8.2 used to calculate C_S ? Yes, but this is N/A to the original design. Seismic Zones were used during design.

Item 4: The diaphragms are rigid as defined in Section 12.3.1 or for diaphragms that are flexible, the distance between the vertical elements of the seismic force-resisting system does not exceed 40ft?

Max. distance between shear walls = 44 ft
Check Rigidity

Disaggregation Report

Disaggregation



Geographical Disaggregation





Parameter Summary

Model: NSHM Conterminous U.S. 2018	Intensity Measure Type: PGA
Latitude: 32.005394°	Return Period: 2475 (2% in 50)
Longitude: -81.172338°	Component: Total
Site Class: DE (Vs30 185)	

Disaggregation Summary

Disaggregation targets	Recovered targets
Return period : 2475 yrs	Return period : 2455.0454 yrs
Exceedance rate : 4.040e-4 yr ⁻¹	Exceedance rate : 4.073e-4 yr ⁻¹
PGA ground motion : 1.926e-1 g	
Totals	Mean (over all sources)
Binned : 100 %	m : 7
Residual : 0 %	r : 99.59 km
Trace : 1.55 %	ε₀ : 0.45 σ
... ..	

Mode (largest m-r bin)

m : 7.3
r : 91.75 km
ε₀ : 0.24 σ
Contribution : 6.58 %

Discretization

r : min = 0.0, max = 1000.0, Δ = 20.0 km
m : min = 4.4, max = 9.4, Δ = 0.2
ε : min = -3.0, max = 3.0, Δ = 0.5 σ

Mode (largest m-r-ε₀ bin)

m : 7.3
r : 109 km
ε₀ : 0.2 σ
Contribution : 2.63 %

Epsilon keys

- ε0 : [-∞ .. -2.5)
- ε1 : [-2.5 .. -2.0)
- ε2 : [-2.0 .. -1.5)
- ε3 : [-1.5 .. -1.0)
- ε4 : [-1.0 .. -0.5)
- ε5 : [-0.5 .. 0.0)
- ε6 : [0.0 .. 0.5)
- ε7 : [0.5 .. 1.0)
- ε8 : [1.0 .. 1.5)
- ε9 : [1.5 .. 2.0)
- ε10 : [2.0 .. 2.5)
- ε11 : [2.5 .. +∞]

Disaggregation Contributions

Source Set	↳	Source	Type	r	m	ε ₀	lon	lat	az	%
Charleston Local Zone			Zone							41.75
		PointSourceFixedStrike: -80.400, 32.600		69.23	7.19	0.14	80.400°W	32.600°N	47.47	1.55
		PointSourceFixedStrike: -80.500, 32.700		71.55	7.19	0.17	80.500°W	32.700°N	39.09	1.5
		PointSourceFixedStrike: -80.300, 32.600		76.24	7.19	0.21	80.300°W	32.600°N	50.88	1.4
		PointSourceFixedStrike: -80.600, 32.800		76.66	7.19	0.22	80.600°W	32.800°N	31.15	1.4
		PointSourceFixedStrike: -80.400, 32.700		77.16	7.19	0.22	80.400°W	32.700°N	43.00	1.38
		PointSourceFixedStrike: -80.500, 32.800		80.80	7.19	0.26	80.500°W	32.800°N	35.36	1.32
		PointSourceFixedStrike: -80.300, 32.700		83.45	7.19	0.28	80.300°W	32.700°N	46.46	1.27
		PointSourceFixedStrike: -80.400, 32.800		85.76	7.19	0.30	80.400°W	32.800°N	39.17	1.23
		PointSourceFixedStrike: -80.600, 32.900		86.76	7.19	0.31	80.600°W	32.900°N	28.21	1.22
		PointSourceFixedStrike: -80.200, 32.700		90.25	7.20	0.34	80.200°W	32.700°N	49.52	1.17
		PointSourceFixedStrike: -80.500, 32.900		90.41	7.19	0.34	80.500°W	32.900°N	32.20	1.16
		PointSourceFixedStrike: -80.300, 32.800		91.41	7.20	0.34	80.300°W	32.800°N	42.59	1.15
		PointSourceFixedStrike: -80.400, 32.900		94.84	7.20	0.37	80.400°W	32.900°N	35.87	1.1
		PointSourceFixedStrike: -80.100, 32.700		97.45	7.20	0.39	80.100°W	32.700°N	52.23	1.06
		PointSourceFixedStrike: -80.200, 32.800		97.61	7.20	0.39	80.200°W	32.800°N	45.67	1.06
		PointSourceFixedStrike: -80.300, 32.900		99.94	7.20	0.41	80.300°W	32.900°N	39.22	1.03
Charleston Narrow Zone			Zone							23.52
		PointSourceFixedStrike: -80.300, 32.800		95.19	7.19	0.38	80.300°W	32.800°N	42.59	1.86
		PointSourceFixedStrike: -80.200, 32.700		96.66	7.19	0.39	80.200°W	32.700°N	49.52	1.83
		PointSourceFixedStrike: -80.200, 32.800		102.52	7.20	0.43	80.200°W	32.800°N	45.67	1.7
		PointSourceFixedStrike: -80.300, 32.900		102.34	7.20	0.43	80.300°W	32.900°N	39.22	1.69
		PointSourceFixedStrike: -80.200, 32.900		109.18	7.20	0.48	80.200°W	32.900°N	42.27	1.55
		PointSourceFixedStrike: -80.100, 32.800		110.16	7.20	0.48	80.100°W	32.800°N	48.44	1.54
		PointSourceFixedStrike: -80.300, 33.000		110.12	7.20	0.48	80.300°W	33.000°N	36.26	1.53
		PointSourceFixedStrike: -80.100, 32.900		116.34	7.21	0.52	80.100°W	32.900°N	45.04	1.41
		PointSourceFixedStrike: -80.200, 33.000		116.46	7.21	0.52	80.200°W	33.000°N	39.24	1.4
		PointSourceFixedStrike: -80.100, 33.000		123.18	7.21	0.57	80.100°W	33.000°N	41.99	1.28
		PointSourceFixedStrike: -80.200, 33.100		121.22	7.22	0.57	80.200°W	33.100°N	36.56	1.27
		PointSourceFixedStrike: -80.300, 33.100		121.22	7.22	0.57	80.300°W	33.100°N	36.56	1.27

PointSourceFixedStrike: -80.200, 33.100	124.28	7.21	0.57	80.200°W	33.100°N	36.56	1.26
PointSourceFixedStrike: -80.000, 33.000	130.22	7.21	0.61	80.000°W	33.000°N	44.52	1.16
PointSourceFixedStrike: -80.100, 33.100	130.58	7.22	0.61	80.100°W	33.100°N	39.26	1.15
PointSourceFixedStrike: -80.200, 33.200	132.54	7.22	0.62	80.200°W	33.200°N	34.18	1.12
PointSourceFixedStrike: -80.000, 33.100	137.23	7.22	0.65	80.000°W	33.100°N	41.76	1.05
PointSourceFixedStrike: -80.100, 33.200	138.46	7.22	0.66	80.100°W	33.200°N	36.81	1.03
Charleston Regional Zone	Zone						17.54
USGS Extended Margin [2] (fixed) (opt)	Grid						5.33
SSCn Mesozoic [4,5] (fixed) (opt)	Grid						5.27
USGS Extended Margin [2] (adaptive) (opt)	Grid						3.21
SSCn Mesozoic [4,5] (adaptive) (opt)	Grid						3.16

Application Metadata

Application: Disaggregation

URL: <https://earthquake.usgs.gov/nshmp/hazard/disagg>

Repository: nshmp-apps

Version: 1.0.11

URL: <https://code.usgs.gov/ghsc/nshmp/nshmp-apps>

Repository : nshmp-haz

Version: 2.4.5

URL: <https://code.usgs.gov/ghsc/nshmp/nshmp-haz>

Repository : nshmp-lib

Version: 1.4.8

URL: <https://code.usgs.gov/ghsc/nshmp/nshmp-lib>

Repository : nshmp-utils-java

Version: 0.4.0

URL: <https://code.usgs.gov/ghsc/nshmp/nshmp-utils-java>

Repository : nshm-conus

Version: 5.2.1

URL: <https://code.usgs.gov/ghsc/nshmp/nshms/nshm-conus>

February 07, 2024, 04:36 AM

SECTION 31 05 19.13

GEOTEXTILES FOR EARTHWORK

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Payment

Payment will be made at the contract unit price and will constitute full compensation to the Contractor for providing all plant, labor, material, and equipment and performing all operations necessary for the complete and satisfactory installation of the geotextile. The following items are included in the contract unit price for Geotextiles and will not be counted a second time in the process of determining the extent of geotextile placed: Material and associated equipment and operation used in laps, seams, or extra length; securing pins and associated material, equipment, and operations; and material and associated equipment and operations used to provide cushioning layer of sand or gravel or both to permit increase in allowable drop height of stone. No payment will be made for geotextiles replaced because of waste, contamination, damage, repair, or due to Contractor fault or negligence.

1.1.2 Measurement

Installed geotextiles will be measured for payment in place to the nearest 200 square feet of protected area as delineated in the drawings.

1.1.3 Unit of Measure

Unit of measure: 200 square feet.

1.2 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D123	(2015b; R 2017) Standard Terminology Relating to Textiles
ASTM D4354	(2012; R 2020) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles

ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D4884/D4884M	(2014a) Strength of Sewn or Thermally Bonded Seams of Geotextiles
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1601	(1991; 1994 Change 1) Engineering and Design -- Hydraulic Design of Flood Control Channels

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Geotextiles

Minimum of 60 days prior to the beginning of installation of the same textile

SD-06 Test Reports

Geotextiles Site Verification

SD-07 Certificates

Geotextiles Needle Punched Geotextile

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver only approved geotextile rolls or panels to the project site. Label, ship, store, and handle all geotextile in accordance with ASTM D4873/D4873M. Do not use hooks, tongs, or other sharp instruments for handling geotextile.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide geotextile that is a non-woven pervious sheet of plastic yarn as defined by [ASTM D123](#) matching or exceeding the minimum average roll values listed in TABLE 1. Strength values indicated in the table are for the weaker principal direction.

TABLE 1 MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE			
PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	lb	115	ASTM D4632/D4632M
SEAM STRENGTH	lb	105	ASTM D4632/D4632M
PUNCTURE	lb	40	ASTM D6241
TRAPEZOID TEAR	lb	40	ASTM D4533/D4533M
PERMEABILITY	cm/sec	0.1	ASTM D4491/D4491M
APPARENT OPENING SIZE	U.S. SIEVE	70	ASTM D4751
PERMITTIVITY	sec ⁻¹	1.4	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	Percent	50 at 500 Hrs	ASTM D4355/D4355M

2.1.2 Geotextile Fiber

Use fibers consisting of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polyamides. Add stabilizers and/or inhibitors to the base polymer, if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Do not add reclaimed or recycled fibers or polymer to the formulation. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile.

2.1.3 Seams

Sew the seams of the geotextile with thread of a material meeting the chemical requirements given above for geotextile yarn or bond the seams by cementing or by heat. Attach the sheets of geotextile at the factory or another approved location, if necessary, to form sections not less than 12 feet wide. Test seams in accordance with method [ASTM D4884/D4884M](#). Seam strength less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction is not permitted.

2.1.4 Securing Pins

Secure the geotextile to the embankment or foundation soil by pins to

prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Insert securing pins through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Remove securing pins as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. Provide maximum pins spacing equal to or less than the values listed in TABLE 2. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the Contracting Officer. Anchor terminal ends of the geotextile with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

TABLE 2 MAXIMUM SPACING FOR SECURING PINS	
EMBANKMENT	SPACING, <i>feet</i>
STEEPER THAN 1V ON 3H	2
1V ON 3H TO 1V ON 4H	3
FLATTER THAN 1V ON 4H	5

2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

2.2.1 Manufacturing and Sampling

Provide *geotextiles* and factory seams meeting the requirements specified in TABLE 1.

2.2.1.1 Conformance Testing

Perform conformance testing in accordance with the manufacturers approved quality control manual. Submit manufacturer's quality control conformance test results.

2.2.1.2 Factory Sampling

Randomly sample geotextiles in accordance with *ASTM D4354* (Procedure Method A). Sample factory seams at the frequency specified in *ASTM D4884/D4884M*. Provide all samples from the same production lot as will be supplied for the contract, of the full manufactured width of the geotextile by at least *10 feet* long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least *5 feet*. Identify samples submitted for testing by manufacturers lot designation.

2.2.1.3 *Needle Punched Geotextile*

For needle punched geotextile, provide manufacturer certification that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

2.2.1.4 Manufacturer Certification

Upon delivery of the geotextile, submit duplicate copies of the written certificate of compliance signed by a legally authorized official of the manufacturer. State that the geotextile shipped to the site meets the chemical requirements and exceeds the minimum average roll value listed in TABLE 1.

2.2.2 Site Verification and Testing

Collect samples at approved locations upon delivery to the site in accordance with ASTM D4354 (Procedure Method B) at a frequency of once per 30,000 square feet. Test samples to verify that the geotextile meets the requirements specified in TABLE 1. Identify samples by manufacturers name, type of geotextile, lot number, roll number, and machine direction. Perform testing at an approved laboratory. Submit test results from the lot under review for approval prior to deployment of that lot of geotextile. Immediately rewrap rolls which are sampled in their protective covering.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of this specification and must be free from obstruction, debris, depressions, erosion feature, or vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Remove loose material, soft or low density pockets of material; grade erosion features such as rills and gullies out of the surface before geotextile placement.

3.2 INSTALLATION OF THE GEOTEXTILE

3.2.1 General

Place the geotextile in the manner and at the locations shown. At the time of installation, reject the geotextile if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

3.2.2 Placement

Place the geotextile to be laid smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 18 inches of overlap for each joint. Adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the bedding layer or riprap is placed will be allowed. Remove the temporary pins as the bedding, granular material, or riprap is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Design protection of riprap in compliance with EM 1110-2-1601. Perform trimming in such a manner that the geotextile is not damaged in any way.

3.3 PROTECTION

Protect the geotextile at all times during construction from contamination by surface runoff; remove any geotextile so contaminated and replaced with

uncontaminated geotextile. Replace any geotextile damaged during its installation or during placement of granular filter materials, bedding materials, or riprap at no cost to the Government. Schedule the work so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply will require replacement of geotextile. Protect the geotextile from damage prior to and during the placement of riprap or other materials. This may be accomplished by limiting the height of drop to less than 1 foot, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials will not impede the flow of water. Before placement of riprap or other materials, demonstrate that the placement technique will not cause damage to the geotextile. Do not allow equipment on the unprotected geotextile.

3.4 PLACEMENT OF CUSHIONING MATERIAL

Perform placing of cushioning material in a manner to ensure intimate contact of the geotextile with the prepared surface and with the cushioning material. Do not damage the geotextile, including tear, puncture, or abrasion, during placement. On sloping surfaces place the cushioning material from the bottom of the slopes upward. During placement, the height of the drop of riprap material greater than 12 inches is not permitted. Uncover any geotextile damaged beneath the cushioning material, as necessary, and replaced at no cost to the Government.

3.5 OVERLAPPING AND SEAMING

3.5.1 Overlapping

The overlap of geotextile rolls or panels must be 18 inches. Appropriate measures will be taken to ensure required overlap exists after cushion placement.

3.5.2 Sewn Seams

High strength thread should be used so that seam test conforms to ASTM D4884/D4884M. Provide thread meeting the chemical, ultraviolet, and physical requirements of the geotextile, and provide color different from that of the geotextile. Provide seam strength equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Use double sewing, specially for field seams, to provide a safety factor against undetected missed stitches.

-- End of Section --

SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Tree Wound Paint

1.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Protection

3.1.1.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.1.2 Trees, Shrubs, and Existing Facilities

Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.1.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing

operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service. Refer to Section 01 30 00 ADMINISTRATIVE REQUIREMENTS and Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS for additional utility protection.

3.2 CLEARING

Clearing consists of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing also includes the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work. Cut off flush with or below the original ground surface trees, stumps, roots, brush, and other vegetation in areas to be cleared, except such trees and vegetation as may be indicated or directed to be left standing. Trim dead branches 1-1/2 inches or more in diameter on trees designated to be left standing within the cleared areas and trim all branches to the heights indicated or directed. Neatly cut close to the bole of the tree or main branches, limbs and branches to be trimmed. Paint, with an approved tree-wound paint, cuts more than 1-1/2 inches in diameter. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.2.1 Tree Removal

Where indicated or directed, remove trees and stumps that are designated as trees from areas outside those areas designated for clearing and grubbing. This work includes the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Dispose of trees as specified in paragraph DISPOSAL OF MATERIALS.

3.2.2 Pruning

Trim trees designated to be left standing within the cleared areas of dead branches 1-1/2 inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1-1/4 inches in diameter with an approved tree wound paint.

3.2.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.3 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, pruning or grubbing such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials is the property of the Contractor and dispose of as specified. All non-saleable timber and wood or wood like materials remaining from timber harvesting such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials is the property of the Contractor and dispose of as specified.

-- End of Section --

SECTION 31 31 16.13
CHEMICAL TERMITE CONTROL

PART 1 GENERAL

1.1 REFERENCES

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

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07 (2019) DOD Pest Management Program

1.2 ADMINISTRATIVE REQUIREMENTS

Coordinate work related to final grades, landscape plantings, foundations, or any other alterations to the finished construction which might alter the condition of treated soils.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Termiticide Application Plan; G

SD-03 Product Data

Termiticides

SD-05 Design Data

Mixing Formulation

SD-06 Test Reports

Soil Moisture

Calibration Test

SD-07 Certificates

Qualifications; G

Foundation Exterior

Utilities and Vents

Crawl and Plenum Air Spaces

List of Equipment

SD-08 Manufacturer's Instructions

Termiticides

SD-11 Closeout Submittals

Verification of Measurement

Warranty

Pest Management Report

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

Comply with **DODI 4150.07** for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent, and submit copies of records when requested by the Contracting Officer. These forms may be obtained from the main web site:

https://www.esd.whs.mil/Directives/forms/fmo_poc/

1.4.2 Qualifications

For the application of pesticides, use the services of an applicator whose principal business is pest control. The applicator must be commercially certified in the state where the work is to be performed as required by **DODI 4150.07**. No contractor personnel may work under the supervision of a certified person even where this is permitted practice in those States or host nations in which the DOD property is located. Termiticide applicators must also be certified in the U.S. Environmental Protection Agency (EPA) pesticide applicator category which includes structural pest control. Submit a copy of the pest control business license and pesticide applicator certificates to the Contracting Officer prior to any applications.

1.4.3 Safety Requirements

Formulate, apply, and dispose of termiticides and their containers in accordance with label directions. Draw water for formulating only from sites designated by the Contracting Officer, and fit the filling hose with a backflow preventer meeting local plumbing codes or standards. Maintain an air gap between the filling hose and tank. Perform filling operations under the direct and continuous observation of a contractor's representative to prevent overflow. Secure pesticides and related materials under lock and key when unattended. Ensure that proper protective clothing and equipment are worn and used during all phases of termiticide application. Dispose of used pesticide containers off Government property.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver termiticide material to the site in the original unopened containers bearing legible labels indicating the EPA registration number, manufacturer's registered uses and in new or otherwise good condition as supplied by the manufacturer or formulator.

1.5.2 Inspection

Inspect termiticides upon arrival at the job site for conformity to type and quality in accordance with paragraph TERMITICIDES. Each label must bear evidence of registration under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended or under appropriate regulations of the host county. Inspect other materials for conformance with specified requirements. Remove unacceptable materials from the job site.

1.5.3 Storage

Storage of pesticides on the installation will not be permitted unless it is written into the contract.

1.5.4 Handling

Handle and mix termiticides in accordance with the manufacturer's label and SDS, preventing contamination by dirt, water, and organic material. Protect termiticides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on pest control vehicles and must be available at the mixing site. Conduct termiticide mixing in an area that has been approved by the Integrated Pest Management Coordinator (IPMC) or Contracting Officer, and with adequate spill containment that can contain at least 110 percent of the volume of the tank.

1.6 SITE CONDITIONS

The following site conditions determine the acceptable time of application.

1.6.1 Soil Moisture

Test soils to be treated immediately before application. Test soil moisture content to a minimum depth of 3 inches. The soil moisture must be as recommended by the termiticide manufacturer. Application of the termiticide is not permitted when soil moisture content exceeds manufacturer's recommendations.

1.6.2 Runoff and Wind Drift

Application of termiticide will not be permitted during or immediately following heavy rains, when conditions may allow runoff, when it may create an environmental hazard or when average wind speed exceeds 10 miles per hour. Termiticide is not permitted to enter water systems, aquifers, or endanger humans or animals.

1.7 WARRANTY

Provide a 5 year written warranty against infestations or reinfestations by subterranean termites of the buildings or building additions

constructed under this contract. Include in the warranty annual inspections of the buildings or building additions during the warranty period. If live subterranean termite infestation or subterranean termite damage is discovered during the warranty period, and the soil and building conditions have not been altered in the interim:

- a. Re-treat the site and perform other treatment as may be necessary for elimination of subterranean termite infestation;
- b. Repair damage caused by termite infestation; and
- c. Reinspect the building approximately 180 days after the re-treatment.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Chemical termite control uses liquid termiticide treatments applied to the soil to form a continuous chemical barrier in the soil around both sides of the foundation. The application can be surface applied or rodded and trenched. This barrier prevents foraging termites from reaching the foundation and piers. Only the soil adjacent to these foundation elements is treated. For slab construction (including foundations, patios and garages), the entire soil (or gravel) surface is treated before the vapor barrier is installed and the slab poured over it. Soil treatment is coordinated with all building activities from foundation construction through final grading of the soil around the building's exterior. In order for the treatment to be effective, the final phase of the application must be done after final grading and sometimes after landscaping is completed so that the treated soil is not disturbed.

2.2 MATERIALS

2.2.1 Termiticides

Provide termiticides currently registered by the EPA or host country. Termiticides must be approved by the Contracting Officer and the Pest Management Consultant prior to use. Select non-repellent termiticides (active ingredient: chlorantraniliprole, chlorfenapyr, fipronil, or imidacloprid) for maximum effectiveness and duration after application. Select a termiticide that is suitable for the soil and climatic conditions at the project site and apply at the highest labeled rate. Submit manufacturer's label and Safety Data Sheet (SDS) for termiticides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

Before termiticide application begins, remove all cellulose containing materials from the site such as wood debris from clearing and grubbing and post construction wood scraps, such as ground stakes, form boards, cardboard paper, and scrap lumber from the site.

3.1.1 Verification

Before work starts, verify that final grades are as indicated and smooth grading has been completed in accordance with Section 31 00 00 EARTHWORK. Finely grade soil and remove particles larger than 1 inch. Compact soil

particles to eliminate soil movement.

3.1.2 Foundation Exterior

If the exterior perimeter treatment is applied before major construction is completed it will be damaged or removed. The exterior foundation perimeter treatment will have to occur in phases during completion of any pads, porches, aprons, sidewalks, final grading, or landscape plantings adjacent to the building foundation. These treatment areas should be coordinated after all major construction but before any pads, porches, or other items requiring special consideration are poured adjacent to the foundation walls. Submit written verification that final grading, landscape planting, and other items adjacent to the foundation will not disturb treatment of the soil on the exterior sides of foundation walls, grade beams, and similar structures.

3.1.3 Utilities and Vents

Turn off and block HVAC ducts and vents located in the treatment area prior to application to protect people and animals from termiticide. Submit written verification that the HVAC ducts and vents, water and sewer lines, and plumbing have been turned off or blocked prior to applying termiticide.

3.1.4 Crawl and Plenum Air Spaces

Submit written verification that crawl and plenum air spaces have been located and identified prior to applying termiticide.

3.1.5 Application Plan

Prior to commencing application of termiticide, submit a [Termiticide Application Plan](#) addressing the following items:

- a. proposed sequence of treatment work including dates and times of application
- b. termiticide trade name
- c. EPA registration number
- d. chemical composition
- e. concentration of original and diluted material
- f. formulation
- g. manufacturer's recommended application rates
- h. regional requirements
- i. application rate of active ingredients
- j. method of application
- k. area or volume to be treated
- l. amount to be applied

- m. copy of the pest control business license
- n. copy of the pesticide applicator certificates

3.2 APPLICATION

For areas to be treated, establish complete and unbroken vertical and horizontal soil chemical barriers between the soil and all portions of the intended structure which may allow termite access to wood and wood related products. Make applications to crawl spaces in accordance with label directions. Applications to crawl space areas that are used as plenum air spaces will not be permitted.

3.2.1 Equipment Calibration and Tank Measurement

Submit a [list of equipment](#) to be used. Conduct [calibration test](#) on the application equipment to be used immediately prior to commencement of termiticide application. Measure the volume and contents of the application tank. Testing must confirm that the application equipment is operating within the manufacturer's specifications and meets the specified requirements. Submit written certification of the equipment calibration test results within one week of testing. Where results from the equipment calibration and tank measurements tests are unsatisfactory, re-treatment will be required.

3.2.2 Mixing and Application

Perform all work related to formulating, mixing, and application in the presence of the Contracting Officer, a DOD certified pesticide applicator, Pest Management Quality Assurance Evaluator (QAE)/Performance Assessment Representative (PAR), or IPMC. Applications must be made at the highest rate or concentration allowed by the label. Submit [mixing formulation](#):

- a. Quantity of pesticide used.
- b. Rate of dispersion.
- c. Percent of use.
- d. Total amount used.

A closed system is recommended as it prevents the termiticide from coming into contact with the applicator or other persons. Only use water from designated locations. Fit filling hoses with a backflow preventer meeting local plumbing codes or standards. Maintain an air gap between filling hoses and tanks. Prevent overflow during the filling operation. Spill kits must be maintained on pest control vehicles and must be available at the mixing site. Termiticide mixing must be conducted in an area that has been designated by the IPMC or Contracting Officer and that has adequate spill containment. Inspect the application equipment prior to each day of use for leaks, clogging, wear, or damage. Immediately perform repairs on the application equipment to prevent or eliminate leaks and clogging.

3.2.2.1 Application Method

3.2.2.1.1 Surface Application

Use surface applications for establishing horizontal barriers. Apply termiticide as a coarse spray and provide uniform distribution over the

soil surface. Termiticide must penetrate a minimum of 1 inch into the soil, or as recommended by the manufacturer. If soils are treated to a depth less than specified or approved, repeat work performed to the depth specified at no additional cost to the Government.

3.2.2.1.2 Rodding and Trenching

Use rodding and trenching for establishing vertical soil barriers. Trenching must be to the depth of the foundation footing. Width of trench must be as recommended by the manufacturer, or as indicated. Rodding or other approved method may be implemented for saturating the base of the trench with termiticide. Backfill the trench immediately after termiticide has reached maximum penetration as recommended by the manufacturer. If maximum penetration is not achieved, as recommended by the manufacturer, repeat work performed to maximum penetration as recommended by the manufacturer at no additional cost to the Government. Backfill in 6 inch rises or layers. Treat each rise or layer with termiticide.

3.2.3 Sampling

The Contracting Officer may draw samples for analysis, at any time and without prior notice, from stocks at the job site to determine if the amount of active ingredient specified on the label is being applied. When analysis, performed by the Government, indicates samples contain less than the amount of active ingredient specified on the label, repeat work performed with pesticides conforming to this specification at no additional cost to the Government.

3.2.4 Vapor Barriers and Waterproof Membranes

Apply termiticide prior to placement of a vapor barrier or waterproof membrane.

3.2.5 Placement of Concrete

Place concrete covering treated soils after the termiticide has reached maximum penetration into the soil as recommended by the manufacturer. Cover treated areas with plastic if slab is not to be poured immediately following termiticide application.

3.2.6 Clean Up, Disposal, and Protection

Once application has been completed, proceed with clean up and protection of the site without delay.

3.2.6.1 Clean Up

Clean the site of all material associated with the treatment according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.6.2 Disposal of Termiticide

Dispose of residual termiticides and containers off Government property, and in accordance with label instructions and EPA criteria.

3.3 FIELD QUALITY CONTROL

3.3.1 [Verification of Measurement](#)

Once termiticide application has been completed, measure tank contents to determine the remaining volume. The total volume measurement of used contents for the application must equal the application rate established in the application plan. Submit written verification that the volume of termiticide used meets the application rate established in the application plan.

3.3.2 Inspection

3.3.2.1 Technical Representative

Provide a technical representative who is a DOD certified pesticide applicator, Pest Management QAE/PAR, or IPMC. The technical representative must be present at all meetings concerning treatment measures for subterranean termites and during treatment application. Contact the IPMC prior to starting work.

3.4 CLOSEOUT ACTIVITIES

Upon completion of this work, submit the [Pest Management Report](#) DD Form 1532, or an equivalent computer product, to the IPMC. This form identifies the target pest, type of operation, brand name and manufacturer of pesticide, formulation, concentration or rate of application used.

3.5 PROTECTION

3.5.1 Protection of Treated Area

Immediately after the application, protect the area from other use by erecting barricades as required or directed. Place signage inside the entrances to crawl spaces and identify the space as treated with termiticide and not safe for children or animals.

3.5.2 Disturbance of Treated Soils

Re-treat soil and fill material disturbed after treatment before placement of slabs or other covering structures.

-- End of Section --

SECTION 32 01 19.61

SEALING OF JOINTS IN RIGID PAVEMENT

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

Determine the quantity of each sealing item to be paid for by actual measurement of the number of linear **ft** of in-place material that has been approved.

1.1.2 Payment

Make payment at the Contract unit bid prices per linear **foot** for the sealing items scheduled. Include the cost of labor, materials, and the use of equipment and tools required to complete the work in the unit bid price.

1.2 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C603	(2014; R 2019) Standard Test Method for Extrusion Rate and Application Life of Elastomeric Sealants
ASTM C639	(2015; R 2020) Standard Test Method for Rheological (Flow) Properties of Elastomeric Sealants
ASTM C661	(2015; R 2022) Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
ASTM C679	(2015; R 2022) Standard Test Method for Tack-Free Time of Elastomeric Sealants
ASTM C719	(2014; R 2019) Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
ASTM C792	(2023) Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
ASTM C793	(2023) Standard Test Method for Effects of Laboratory Accelerated Weathering on Elastomeric Joint Sealants

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C1016	(2014; R 2022) Standard Test Method for Determination of Water Absorption of Sealant Backing (Joint Filler) Material
ASTM C1193	(2016) Standard Guide for Use of Joint Sealants
ASTM D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D789	(2015) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)
ASTM D903	(1998; R 2017) Standard Test Method for Peel or Stripping Strength of Adhesive Bonds
ASTM D5249	(2010; R 2016) Standard Specification for Backer Material for Use with Cold-and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D5329	(2016) Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphalt Pavements and Portland Cement Concrete Pavements
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	(2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 525	(1989) Corps of Engineers Test Method for Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sealants

Submit catalog cuts, specifications, Safety Data Sheets and other information documenting conformance to Contract requirements.

Manufacturer's Recommendations

SD-04 Samples

Sealants

Provide for testing a 5-gal sample of each sealant with associated primer to the Contracting Officer a minimum of 60 days prior to its use on the job. Provide factory-sealed containers with a factory applied label showing the following information:

- Name of sealant
- Identification of component, or primer
- Specification number and type
- Manufacturer's name
- Manufacturer's lot and batch number
- Date of Manufacture (month and year)
- Shelf life retest date (month and year)
- List of hazardous components
- Quantity of material in container (volume)
- Storage instructions
- Instructions for use

Blocking Media/Backup Materials

Backer Rod

Bond Breaking Tapes

SD-06 Test Reports

Sealants

SD-07 Certificates

Equipment List

SD-08 Manufacturer's Instructions

Sealants

Provide instructions that include, but not limited to: storage requirements, ambient temperature and humidity ranges, and moisture condition of joints for successful installation; requirements for preparation of joints; safe heating temperature; mixing instructions; installation equipment and procedures;

application and disposal requirements; compatibility of sealant with filler material; curing requirements; and restrictions to be adhered to in order to reduce hazards to personnel or to the environment. Submit instructions at least 30 days prior to use.

1.4 QUALITY ASSURANCE

1.4.1 Test Requirements

Test the sealant and backup or separating material for conformance with the referenced material specification. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 14 days prior to the use of the materials at the job site. Submit samples to be retained by the Government for possible future testing if the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified does not constitute final acceptance of the materials. Base final acceptance on the performance of the in-place materials. Submit samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval 7 days prior to the beginning of work. Do not use material until it has been approved.

1.4.2 Trial Joint Sealant Installation

Prior to cleaning and sealing the joints for the entire project, prepare a test section at least 200 ft long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of the types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. Inspect joint seal test section. Provide written notice of deficiencies and required corrections or adjustments in the joint seal installation procedures. Correct deficiencies and obtain approval of test section prior to installing joint seals. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. Permit the test section meeting the requirements to be incorporated into the permanent work and paid for at the Contract unit price per linear foot for sealing items scheduled. Prepare and seal other joints in the manner approved for sealing the test section. Notify the Contracting Officer upon completion of the test section.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for visible damage, and unload and store with a minimum of handling. Deliver joint materials in original sealed containers and protect from freezing or overheating. Provide jobsite storage facilities capable of maintaining temperature ranges within manufacturers recommendations.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not proceed with work when weather conditions detrimentally affect the quality of cleaning joints or applying sealants. Proceed with joint preparation and sealing only when weather conditions are in accordance with manufacturer's instructions. Install joint sealant to dry surfaces and protect sealant and bond breakers from moisture.

1.7 TRAFFIC CONTROL

Do not permit vehicular or heavy equipment traffic on the pavement in the area of the joints being sealed during the protection and curing period of the sealant. Permit traffic on the pavement at the end of the curing period.

PART 2 PRODUCTS

2.1 SEALANTS

Use materials for sealing cracks in accordance with [ASTM D6690](#) and [ASTM D5893/D5893M](#) based on the type of area as follows:

Use self leveling, non-acid curing silicone sealant meeting the following requirements in accordance with [ASTM C920](#) or [ASTM C1193](#):

TEST	TEST METHOD	REQUIREMENTS
Weight Loss	ASTM C792 Modified (see Note 1 below)	10 percent max.
Flow	ASTM C639 (Type I)	Smooth and level
Extrusion Rate	ASTM C603	30 sec. max.
Tack Free Time	ASTM C679	5 hours max.
Hardness (Shore 00) (see Note 2 below)	ASTM C661	30 - 80
Tensile Stress at 150 Percent Elongation (see Note 2 below)	ASTM D412 (Die C)	30 psi max.
Percent Elongation (see Note 2 below)	ASTM D412 (Die C)	700 min.
Accelerated Weathering	ASTM C793	Pass 5000 hours
Bond and Movement Capability	ASTM C719	Pass 10 cycles at plus 50 percent movement (no adhesion or cohesion failure)
Peel	ASTM D903	Minimum 20 psi of width with at least 75 percent cohesive failure
NOTES: 1. Percent weight loss of wet (uncured) sample after placing in forced-draft oven maintained at 158 degrees plus 1 degree F for two hours. 2. Specimen cured 21 days at 73 degrees plus 1 degree F and 50 percent plus 5 percent humidity.		

ACCELERATED WEATHERING FACTORY TEST REPORT. For the Accelerated

Weathering test, in lieu of testing of actual sealant to be used on the project, it is permitted to submit a report of a factory test, performed within two years of Contract award.

2.2 PRIMERS

Use primers in accordance with the recommendation of the manufacturer.

2.3 BOND BREAKERS

2.3.1 Blocking Media/Backup Materials

Provide backup (joint filler) material that is a compressible, nonshrinking, nonstaining, nonabsorbing, nonreactive material with the sealant. Use backup material compliant with [ASTM D5249](#). Use material with a melting point at least [5 degrees F](#) greater than the pouring temperature of the sealant being used when tested in accordance with [ASTM D789](#). Use material with a water absorption of not more than 5 percent of the sample weight when tested in accordance with [ASTM C1016](#). Use backup (joint filler) material that is 25 plus or minus 5 percent larger in diameter than the nominal width of the crack. Use blocking media consistent with the sealant manufacturer's installation instructions.

2.3.2 Bond Breaking Tapes

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. Use material with a melting point at least [5 degrees F](#) greater than the pouring temperature of the sealant being used when tested in accordance with [ASTM D789](#). Use bond breaker tape approximately [1/8 in](#) wider than the nominal width of the joint and that does not bond to the sealant. Use bond breaking tape consistent with the sealant manufacturer's installation instructions.

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

Submit [equipment list](#) and description of the equipment to be used and a statement from the supplier of the sealant that the proposed equipment is acceptable for installing the specified sealant. Use equipment for heating, mixing, and installing seals in accordance with the instructions provided by the sealant manufacturer. Provide equipment, tools, and accessories necessary to clean existing joints and install liquid joint sealants. Maintain machines, tools, and other equipment in proper working condition. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, [7](#) days prior to use on the project.

3.1.1 Joint Cleaning Equipment

3.1.1.1 Tractor-Mounted Routing and Plowing Tool

Use routing tools for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that do not damage the sides of the joints. Use tools designed to be adjusted to remove the old material to varying depths and widths as required. Use equipment capable of maintaining accurate cutting depth and width control. Use a joint plow equipped with a spring or hydraulic mechanism to release pressure on the tool prior to spalling the concrete. Do not permit the use of V-shaped tools or rotary impact routing devices. Permit the use of hand-operated

spindle routing devices to clean and enlarge random cracks.

3.1.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified, for refacing joints, cleaning sawed joints where sandblasting does not provide a clean joint, widening, or deepening existing joints as specified without damaging the sides, bottom, or top edge of joints. Permit single or gang type blades with one or more blades mounted in tandem for fast cutting. Select saw adequately powered and sized to cut specified opening with not more than two passes of the saw through the joint.

3.1.1.3 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. Do not permit the maximum nozzle opening to exceed $\frac{1}{4}$ in. Use a portable air compressor capable of providing not less than 150 cfm and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. Use a compressor equipped with traps that maintain the compressed air free of oil and water. Use a nozzle with an adjustable guide that holds the nozzle aligned with the joint approximately 1 in above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle to secure satisfactory results.

3.1.1.4 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. Use a nozzle with an adjustable guide that holds the nozzle aligned with the joint approximately 1 in above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle to obtain satisfactory results. Use a pressure gauge mounted at the pump that shows the pressure in psi at which the equipment is operating.

3.1.1.5 Air Compressor

Use a portable air compressor capable of operating the sandblasting equipment and capable of blowing out sand, water, dust adhering to sidewalls of concrete, and other objectionable materials from the joints. Use a compressor that provides air at a pressure not less than 90 psi and a minimum rate of 150 cubic ft of air per minute at the nozzles and free of oil.

3.1.1.6 Vacuum Sweeper

Use a self-propelled, vacuum pickup sweeper capable of completely removing loose sand, water, joint material, and debris from pavement surface.

3.1.1.7 Hand Tools

Permit the use of hand tools, such as brooms and chisels, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

3.1.2 Sealing Equipment

Use joint sealing equipment of a type required by the sealant manufacturer's installation instructions. Use equipment capable of installing sealant to the depths, widths and tolerances indicated. Do not proceed with joint sealing when malfunctions are noted until the malfunctions are corrected.

3.1.2.1 Hot-Poured Sealing Equipment

Use mobile unit applicators equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer for heating and installing **ASTM D6690** joint sealant materials; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording thermometer for indicating the temperature of the sealant. Use an applicator unit designed so that the sealant circulates through the delivery hose and returns to the inner kettle when not in use.

3.1.2.2 Cold-Applied, Single-Component Sealing Equipment

Use equipment for installing **ASTM D5893/D5893M** single component joint sealants that consists of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. Use a nozzle with dimensions that allows the tip of the nozzle to extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Use lined hoses and seals to prevent moisture penetration and withstand pumping pressures. Use equipment free of contamination from previously used or other type sealant. Permit use of small hand-held air-powered equipment (i.e., caulking guns) for small applications.

3.2 PREPARATION OF JOINTS

Unless otherwise indicated, remove existing material, saw, clean and reseal joints. Do not proceed with final cleaning operations by more than one working day in advance of sealant. Clean joints by removing existing joint sealing compound, bond-breakers, dirt, laitance, curing compound, filler, and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed and other foreign material with the equipment. Do not permit cleaning procedures that damage joints or previously repaired patches by chipping or spalling. Remove existing sealant to the required depth. Precise shape and size of existing joints vary, and conditions of joint walls and edges vary and include but are not limited to rounding, square edges, sloping, chips, voids, depressions, and projections.

3.2.1 Sawing

3.2.1.1 Facing of Joints

Accomplish facing of joints using a concrete saw as specified in paragraph **EQUIPMENT to loosen and remove material until the joint is clean and open to the full specified width and depth.** Provide exposure of newly clean concrete through removal. Remove burrs and irregularities from sides of joint faces. Stiffen the blade with a sufficient number of dummy (used)

blades or washers. Clean, immediately following the sawing operation, the joint opening using a water jet to remove saw cuttings and debris and adjacent concrete surface. Protect adjacent previously cleaned joint spaces from receiving water and debris during the cleaning operation.

- a. Joint Widening (Except Expansion Joints): Saw joints having grooves less than $\frac{3}{8}$ in wide and less than 1 in deep to a minimum width of $\frac{3}{8}$ in and to the minimum depth, 1 in .

3.2.1.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in paragraph EQUIPMENT. Use a saw blade 6 in or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade with dummy (or used) blades or washers. Immediately following the sawing operation, clean the crack opening using a water jet to remove saw cuttings and debris.

3.2.2 Final Cleaning of Joints

3.2.2.1 Sandblasting

Following removal of existing sealant, and sawing, and immediately before resealing, clean newly exposed concrete joint faces and pavement surface extending to a minimum of $\frac{1}{2}$ in up to 2 in from each joint edge by sandblasting until concrete surfaces in the joint space are free of sealants, dust, dirt, water and other foreign materials that prevent bonding of new sealants to the concrete. Use sand particles of the proper size and quality for the work. Perform sandblasting with specified nozzles, air compressor, and other appurtenant equipment. Position nozzles to clean the joint faces. Make at least two passes; one for each joint face. Make as many passes as required for proper cleaning. Immediately prior to sealing the joint, blow out the joint spaces with compressed air until completely free of sand, water, and dust. Install joint sealants to dry joints. Replace expansion joint filler material damaged in performing the work with new materials of the same type and dimensions as the existing material, or with appropriate blocking media.

3.2.3 Bond Breaker

At the time the joints receive the final cleaning and are dry, install bond breaker material as indicated with a steel wheel or other approved device.

3.2.3.1 Blocking Media (Backer Rod) (Except for Expansion Joints)

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a blocking media/back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the blocking media/backup material is placed at the specified depth and is not stretched or twisted during installation.

3.2.3.2 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Bond the tape to the

bottom of the joint opening to prevent it from floating up into the new sealant.

3.2.4 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, including sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.2.5 Disposal of Debris

Sweep pavement surface to remove excess joint material, dirt, water, sand, and other debris by vacuum sweepers or hand brooms. Remove the debris immediately to a point off station. .

3.3 PREPARATION OF SEALANT

3.3.1 Hot-Poured Sealants

Heat hot-poured sealing materials in accordance with [ASTM D6690](#) and with safe heating temperature ranges recommended by the manufacturer. Withdraw and waste sealant that has been overheated or subjected to heating for over 3 hours or that remain in the applicator at the end of the day's operation. Heat sealant in specified equipment.

3.3.2 Single-Component, Cold-Applied Sealants

Inspect the [ASTM D5893/D5893M](#) sealant and containers prior to use. Reject materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Do not reject sealants that exhibit settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools.

3.4 INSTALLATION OF SEALANT

3.4.1 Time of Application

After approval of the test section, seal joints immediately following final cleaning and placing of bond breakers. Commence sealing joints when walls are dust free and dry, and when weather conditions meet sealant manufacturer's instructions. If the above conditions cannot be met, or when rain interrupts sealing operations, reclean and permit the joints to dry prior to installing the sealant.

3.4.2 Sealing Joints

Do not install joint sealant until joints to be sealed have been inspected and approved. Install bond breaker just prior to pouring sealant. Fill the joints with sealant from bottom up until joints are uniformly filled solid from bottom to top using the specified equipment for the type of sealant required. Fill joints to $\frac{1}{4}$ in plus or minus $\frac{1}{16}$ in below top of pavement, and without formation of voids or entrapped air. Do not permit gravity methods or pouring pots to be used to install the sealant material. Except as otherwise permitted, tool the sealant immediately after application to provide firm contact with the joint walls and to form the indicated sealant profile below the pavement surface. Remove excess sealant that has been inadvertently spilled on the pavement surface. Do not permit traffic over newly sealed pavement until authorized. When a primer is recommended by the manufacturer, apply it evenly to the joint

faces in accordance with the [manufacturer's recommendations](#). Check sealed joints frequently to ensure that newly installed sealant is cured to a tack-free condition within the specified time. Protect new sealant from rain during curing period.

3.5 INSPECTION/FIELD QUALITY CONTROL

3.5.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Approve cleaned joints prior to installation of the separating or back-up material and joint sealant.

3.5.2 Sampling Sealant

Obtain a [one gal](#) sample of each type of sealant on the project from material used for each [10,000 linear ft](#) or less of joints sealed. Store samples according to sealant manufacturer's instructions. Retain samples until final acceptance of the work.

3.5.3 Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Suspend operations if there is evidences of bubbling, improper installation, or failure to cure or set until causes of the deficiencies are determined and corrected.

3.5.4 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Remove sealants exhibiting these deficiencies prior to the final acceptance of the project from the joint, wasted, and replace at no additional cost to the Government. Obtain approval for each joint seal installation.

3.6 ACCEPTANCE

Reject sealer that fails to cure properly, or fails to bond to joint walls, or reverts to the uncured state, or fails in cohesion, or shows excessive air voids, blisters, surface defects, swelling, or other deficiencies, or is not properly recessed within indicated tolerances. Remove rejected sealer and reclean and reseal joints. Perform removal and reseal work promptly by and at the expense of the Contractor.

3.7 CLEAN-UP

Upon completion of the project, remove unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

SECTION 32 05 33

LANDSCAPE ESTABLISHMENT

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D6155 (2019) Nontraditional Coarse Aggregate for Bituminous Paving Mixtures

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA Z133 (2017) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

1.2 DEFINITIONS

1.2.1 Pesticide

Any substance or mixture of substances, including biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the U.S. Environmental Protection Agency (EPA). Also, any substance used as a plant regulator, defoliant, disinfectant, or biocide. Examples of pesticides include fumigants, herbicides, insecticides, fungicides, nematicides, molluscicides and rodenticides.

1.2.2 Stand of Turf

100 percent ground cover of the established species.

1.2.3 Planter Beds

A planter bed is defined as an area containing one or a combination of the following plant types: shrubs, vines, wildflowers, annuals, perennials, ground cover, and a mulch topdressing excluding turf. Trees may also be found in planter beds.

1.3 RELATED REQUIREMENTS

Section 32 92 19 SEEDINGSection 32 92 23 SODDING applies to this section for installation of seedsod requirements, with additions and modifications herein.

Section 32 93 00 EXTERIOR PLANTS applies to this section for installation of trees, shrubs, ground cover, and with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Integrated Pest Management Plan; G, R0

SD-03 Product Data

Fertilizer; G, R0

Mulches Topdressing

Organic Mulch Materials

SD-07 Certificates

Maintenance Inspection Report

Plant Quantities; G, R0

SD-11 Closeout Submittals

Tree Staking and Guying Removal

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Delivery

Deliver fertilizer, gypsum, iron to the site in original containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum may be furnished in bulk with a certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Fertilizer, Lime, Iron, Mulch Storage

Store material in designated areas. Store lime and fertilizer in cool, dry locations away from contaminants.

1.5.2.2 Antidesiccant's Storage

Do not store with fertilizers or other landscape maintenance materials.

1.5.3 Handling

Do not drop or dump materials from vehicles.

PART 2 PRODUCTS

2.1 POST-PLANT FERTILIZER

2.1.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

- 6 percent available nitrogen
- 12 percent available phosphorus
- 12 percent available potassium

2.2 WATER

Source of water must be approved by the Contracting Officer, and be of suitable quality for irrigation.

2.3 MULCHES TOPDRESSING

Free from noxious weeds, mold, or other deleterious materials.

2.3.1 Inert Mulch Materials

Provide riverbank stone, complying with ASTM D6155, ranging in size from 0.5 to 2 inches.

2.3.2 Organic Mulch Materials

Provide pine straw mulch, or from site when available. Wood cellulose fiber must be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch must contain a minimum of 100 percent post-consumer recycled content. Wood-based hydraulic mulch must contain a minimum of 100 percent total recovered materials content.

2.3.3 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 2-1/2 by 2-1/2 inch screen. Clean recycled mulch of all sticks a minimum one inch in diameter and plastic materials a minimum 3 inch length. The material must be treated to retard the growth of mold and fungi.

2.4 PESTICIDES

Submit an Integrated Pest Management Plan, including weed and pest management strategies proposed alternatives to herbicides and pesticides. Use biological pest controls as approved in the Plan.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide landscape construction maintenance to include irrigation equipment cleaning and adjustments, fertilizing, watering, stake and guy adjusting, for all newly installed landscape areas , unless indicated otherwise, and at all areas inside or outside the limits of the construction that are

disturbed by the Contractor's operations.

3.1.1 Policing

Police all landscaped areas. Policing includes removal of leaves, branches and limbs regardless of length or diameter, dead vegetation, paper, trash, cigarette butts, garbage, rocks or other debris. Collected debris must be promptly removed and disposed of at an approved disposal site.

3.1.2 Drainage System Maintenance

Remove all obstructions from surface and subsurface drain lines to allow water to flow unrestricted in swales, gutters, catch basins, storm drain curb inlets, and yard drains. Remove grates and clear debris in catch basins. Open drainage channels are to be maintained free of all debris and vegetation at all times. Edges of these channels must be clear of any encroachment by vegetation.

3.2 IRRIGATION ESTABLISHMENT PERIOD

The irrigation establishment period will commence on the date that inspection by the Contracting Officer shows that the new irrigation equipment furnished under this contract have been satisfactorily installed and is functional and must continue for a period of 365 days.

3.2.1 Maintenance During the Irrigation Establishment Period

Begin maintenance immediately after irrigation equipment has been installed and is functional. Inspect irrigation equipment at least once a week during the installation and establishment period and perform needed maintenance promptly. Automatic controllers not equipped with rain shut-off sensors must be turned off during periods of rain that exceed twelve hours of continuous rainfall in one day or during rain storms of one day or more. Once the rain has subsided timers must be reactivated. Irrigation controllers must be inspected and reprogrammed after power outages. Contractor must be responsible for winterization and startup. Sprinkler heads must direct water away from buildings and hard surfaced areas.

3.2.2 Water Restrictions

Abide by state, local or other water conservation regulations in force during the establishment period. Automatic controller must be adjusted to comply with the water conservation regulations schedule.

3.2.3 Fire Hydrants

To use a fire hydrant for irrigation, obtain prior clearance from the Contracting Officer and provide the tools and connections approved for use on fire hydrants. If a fire hydrant is used, Provide a reduced pressure backflow preventer for each connection between hose and fire hydrant. Backflow preventer used must be tested once per month by a certified backflow preventer tester.

3.2.4 Final Acceptance

Upon completion of the irrigation establishment period and final acceptance of groundcover and exterior plants, irrigation equipment must

be removed.

3.3 GROUNDCOVER ESTABLISHMENT PERIOD

Groundcover establishment period will commence on the date that inspection by the Contracting Officer shows that the new turf furnished under this contract has been satisfactorily installed to a 100 percent stand of coverage. The establishment period must continue for a period of 365 days.

3.3.1 Frequency of Maintenance

Begin maintenance immediately after turf has been installed . Inspect area once a week during the installation and establishment period and perform needed maintenance promptly.

3.3.2 Promotion of Growth

Maintain groundcover in a manner that promotes proper health, growth, natural color. Turf must have a neat uniform manicured appearance, free of bare areas, ruts, holes, weeds, pests, dead vegetation, debris, and unwanted vegetation that present an unsightly appearance. Mow, remove excess clippings, eradicate weeds, water, fertilize, and perform other operations necessary to promote growth, as approved by Contracting Officer and consistent with approved Integrated Pest Management Plan. Remove noxious weeds common to the area from planting areas by mechanical means.

3.3.3 Post-Fertilizer Application

Apply turf fertilizer in a manner that promotes health, growth, vigor, color and appearance of cultivated turf areas. The method of application, fertilizer type and frequencies must be determined by the laboratory soil analysis results the requirements of the particular turf species. Organic fertilizer must be used. In the event that organic fertilizer is not producing the desired effect, the Contractor must contract the Contracting Officer for approval prior to the use of a synthetic type of fertilizer. Apply fertilizer by approved methods in accordance with the manufacturer's recommendations.

3.3.4 Turf Watering

Perform irrigation in a manner that promotes the health, growth, color and appearance of cultivated vegetation and that complies with all Federal, State, and local water agencies and authorities directives. The Contractor must be responsible to prevent over watering, water run-off, erosion, and ponding due to excessive quantities or rate of application. Abide by state, local or other water conservation regulations or restrictions in force during the establishment period..

3.3.5 Turf Clearance Area

Trees located in turf areas must be maintained with a growth free clearance of 18 inches from the tree trunk base. The use of mechanical weed whips to accomplish the turf growth free bed area is prohibited.

3.3.6 Replanting

Replant in accordance with Section 32 92 19 SEEDINGSection 32 92 23 SODDING and within specified planting dates areas which do not have a satisfactory stand of turf.

3.3.7 Final Inspection and Acceptance

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the turf establishment period. Final turf acceptance will be based upon a satisfactory stand of turf.

3.4 EXTERIOR PLANT ESTABLISHMENT PERIOD

The exterior plant establishment period will commence on the date that inspection by the Contracting Officer shows that the new plants furnished under this contract have been satisfactorily installed and must continue for a period of 365 days.

3.4.1 Frequency of Maintenance

Begin maintenance immediately after plants have been installed. Inspect exterior plants at least once a week during the installation and establishment period and perform needed maintenance promptly.

3.4.2 Promotion of Plant Growth and Vigor

Water, prune, fertilize, mulch, adjust stakes, guys and turnbuckles, eradicate weeds and perform other operations necessary to promote plant growth, and vigor.

3.4.3 Planter Bed Maintenance

Planter beds must be weeded, fertilized, irrigated, kept pest free, turf free, pruned, and mulch levels maintained. Planter beds will not be allowed to encroach into turf areas. A definite break must be maintained between turf areas and planter beds.

3.4.3.1 Shrub Selective Maintenance

In addition to the above requirements, shrubs must be selectively pruned, and shaped for health and safety when the following conditions exist: Remove growth in front of windows, over entrance ways or walks, and any growth which will obstruct vision at street intersections or of security personnel; Remove dead, damaged or diseased branches or limbs; where shrub growth obstructs pedestrian walkways; where shrub growth is found growing against or over structures; where shrub growth permits concealment of unauthorized persons. Dispose of all pruning debris in a proper manner.

3.4.3.2 Tree Maintenance

Tree maintenance must include adjustment of stakes, ties, guy supports , watering, fertilizing, pest control, mulching, pruning for health and safety . Inspect and adjust stakes, ties, guy supports to avoid girdling and promote natural development. All trees within the project boundaries, regardless of caliper, must be selectively pruned for safety and health reasons. These include but are not limited to removal of dead and broken branches and correction of structural defects. Prune trees according to their natural growth characteristics leaving trees well shaped and balanced. Pruning of all trees including palm trees must be accomplished by or in the presence of a certified member of the International Society of Arboriculture and in accordance with [TCIA Z133](#). All pruning debris generated must be disposed of in a proper manner.

3.4.4 Slope Erosion Control Maintenance

Provide slope erosion control maintenance to prevent undermining of all slopes in newly landscaped . Maintenance tasks include immediate repairs to weak spots in sloped areas, and maintaining clean, clear culverts, and graded berms, to intercept and direct water flow to prevent development of large gullies and slope erosion and during periods of extended rainfall, irrigation systems must be secured. Eroded areas must be filled with amended topsoil and replanted with the same plant species. Erosion control blankets damaged due to slope erosion must be reinstalled.

3.4.5 Removal of Dying or Dead Plants

Remove dead and dying plants and provide new plants immediately upon commencement of the specified planting season, and replace stakes, mulch and eroded earth mound water basins. Provide an additional 90 day establishment period for replacement plants beyond the original warranty period. A tree must be considered dying or dead when the main leader has died back, or a minimum of 20 percent of the crown has died. A shrub or ground cover must be considered dying or dead when a minimum of 20 percent of the plant has died. This condition must be determined by scraping on a branch an area 1/16 inch square, maximum, to determine the cause for dying plant material and must provide recommendations for replacement. The Contractor must determine the cause for dying plant material and provide recommendations for replacement.

3.4.6 Tracking of Unhealthy Plants

Note plants not in healthy growing condition, as determined by the Contracting Officer, and as soon as seasonal conditions permit, remove and replace with plants of the same species and sizes as originally specified. Install replacement plantings in accordance with Section 32 93 00 EXTERIOR PLANTS.

3.4.7 Final Inspection

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the establishment period. Final inspection will be based upon satisfactory health and growth of plants and on the following:

3.4.7.1 Total Plants on Site

Plants have been accepted and required number of replacements have been installed.

3.4.7.2 Mulching and Weeding

Planter beds and earth mound water basins are properly mulched and free of weeds.

3.4.7.3 Tree Supports

Stakes guys guys and turnbuckles are in good condition.

3.4.7.4 Remedial Work

Remedial measures directed by the Contracting Officer to ensure plant material survival and promote healthy growth have been completed.

3.5 FIELD QUALITY CONTROL

3.5.1 Maintenance Inspection Report

Provide maintenance inspection report to assure that landscape maintenance is being performed in accordance with the specifications and in the best interest of plant growth and survivability. Site observations must be documented at the start of the establishment period, then quarterly following the start, and at the end of establishment period. Submit results of site observation visits to the Contracting Officer within 7 calendar days of each site observation visit.

3.5.2 Plant Quantities

Provide Contracting Officer with the number of plant quantities. In addition, provide total exterior area of hardscape and landscaping such as turf and total number of shrubs.

3.5.3 Tree Staking and Guying Removal

Provide a certified letter that all stakes and guys are removed from all project trees at the end of the establishment period.

-- End of Section --

SECTION 32 11 20

BASE COURSE FOR RIGID PAVING

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow

Depth)

ASTM D7928

(2017) Standard Test Method for
Particle-Size Distribution (Gradation) of
Fine-Grained Soils Using the Sedimentation
(Hydrometer) Analysis

ASTM E11

(2022) Standard Specification for Woven
Wire Test Sieve Cloth and Test Sieves

1.2 DEGREE OF COMPACTION

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the laboratory maximum dry density in accordance with ASTM D1557 Method C and corrected with ASTM D4718/D4718M.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G, R0

SD-06 Test Reports

Initial Tests; G, R0

In-Place Tests; G, R0

1.4 QUALITY ASSURANCE

Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Do not start work requiring testing until the testing laboratory has been inspected and approved. All contractor quality control testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and on-site laboratory. Validation on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at <https://mtc.erdcdren.mil/requestvalidation.aspx#> for costs and scheduling. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. Furnish copies of test results within 24 hours of completion of the tests.

1.4.1 Sampling

Take samples for laboratory testing in conformance with [ASTM D75/D75M](#).

1.4.2 Tests

1.4.2.1 Gradation

Perform gradation in conformance with [ASTM C117](#) and [ASTM C136/C136M](#) using sieves conforming to [ASTM E11](#). Perform particle-size analysis of the soils in conformance with [ASTM D7928](#).

1.4.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with [ASTM D4318](#).

1.4.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with paragraph DEGREE OF COMPACTION.

1.4.2.4 Field Density Tests

Measure field density in accordance with [ASTM D1556/D1556M](#), or [ASTM D6938](#). For the method presented in [ASTM D1556/D1556M](#), use the base plate, as shown in the drawing. For the method presented in [ASTM D6938](#), check the calibration curves and adjust them, if necessary, using only the sand cone method as described in Annex A2, of the ASTM publication. Use [ASTM D6938](#) to determine the moisture content of the soil. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in [ASTM D6938](#). Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in Annex A2, in [ASTM D6938](#), on each different type of material to be tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.4.2.5 Wear Test

Perform wear tests on rigid pavement base course material in conformance with [ASTM C131/C131M](#).

1.5 ACCEPTANCE

1.5.1 Tolerances

Acceptance of rigid pavement base course is based on compliance with the tolerances presented in Table 1. Remove and replace any course identified by the failing tests.

TABLE 1	
Measurement	Tolerance
Grade	Plus 0, Minus 1/2 inch

TABLE 1	
Smoothness	Plus/Minus 1/2 inch
Total Thickness	Plus/Minus 1/2 inch
Average Job Thickness	Plus/Minus 1/4 inch
Compaction	
Rigid Pavement Base Course	Minimum 100 percent

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Limit the percentage of loss to a maximum of 50 percent after 500 revolutions when tested in accordance with [ASTM C131/C131M](#). Provide aggregates with at least 75 percent by weight retained on each sieve having one freshly fractured face with the area at least equal to 75 percent of the smallest midsectional area of the piece. Provide aggregate that is reasonably uniform in density and quality. Provide aggregates having a maximum size of 2 inches, a minimum of 70 percent passing the 3/4 inch sieve, and within the limits specified as follows:

TABLE 3	
Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve	
Sieve Designation	Rigid Pavement Base Course
No. 10	85
No. 200	15

Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with [ASTM D7928](#). Limit the portion of any blended component and of the completed course passing the No. 40 sieve to be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 6. Provide any additional stability required to maintain a working platform for construction equipment. If a test section can demonstrate that a material has adequate stability to support construction equipment, the fractured face requirement can be deleted, subject to approval by the Government.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Initial Tests

Perform one of each of the following [Initial Tests](#) on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation. Complete this testing for each source if materials from more than one source are proposed.

- a. Gradation .
- b. Liquid limit and plasticity index.
- c. Moisture-density relationship.
- d. Wear.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.2.2 Approval of Material

Tentative approval of material will be based on initial test results.

2.3 EQUIPMENT, TOOLS, AND MACHINES

All [plant, equipment, and tools](#) used in the performance of the work are subject to approval by the Government before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Condition aggregate sources on private lands in accordance with local laws and authorities. Clear, strip and excavate as required. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the rigid pavement base course. Do not construct rigid pavement base course on underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in [ASTM D2487](#), stabilize the surface prior to placement of the overlying course. Stabilize by mixing the overlying course material into the underlying course and compacting by approved methods. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the overlying course is placed.

3.5 GRADE CONTROL

Provide a finished and completed rigid pavement base course conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material at the water content specified. Make such adjustments in mixing or placing procedures or in equipment as directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to provide a satisfactory course.

3.7 LAYER THICKNESS

Compact the completed course to the thickness indicated. Limit individual compacted lifts to a maximum thickness of [6 inches](#) and a minimum thickness of [3 inches](#). Compact the course(s) to a total thickness that is within the tolerances of paragraph ACCEPTANCE. Where the measured thickness is more than [1/2 inch](#) deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than [1/2 inch](#) thicker than indicated, the course will be considered as conforming to the specified thickness requirements. However, the requirements for the overlying course thickness and plan grade are still applicable. The average job thickness will be the average of all thickness measurements taken for the job and within the tolerances of paragraph ACCEPTANCE.

3.8 COMPACTION

Compact each lift of the material, as specified, with approved compaction equipment. For cohesive soils, maintain water content during the compaction procedure to within plus or minus 2 percent of optimum water content determined from laboratory tests as specified in this Section and for cohesionless soils, maintain a water content to facilitate compaction without bulking. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half

the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction of the rigid pavement base until each lift is compacted through the full depth to meet the compaction requirements of Table 1. Make such adjustments in compacting or finishing procedures to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a compliant rigid pavement base course. Remove any materials that are found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification.

3.9 EDGES OF RIGID PAVEMENT BASE COURSE

Place approved material along the outer edges of the rigid pavement base course in sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more lifts, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each lift of the rigid pavement base course, as directed.

3.10 FINISHING

Finish the surface of the top lift of rigid pavement base course after final compaction by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin lifts of material to the top lift of rigid pavement base course to meet grade. If the elevation of the top lift of rigid pavement base course exceeds the tolerances of paragraph ACCEPTANCE, scarify the top lift to a depth of at least 3 inches and blend new material in and compact to bring to grade. Make adjustments to rolling and finishing procedures to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable rigid pavement base course. If the surface becomes rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the non-compliant portion and rework and recompact it or replace as directed.

3.11 SMOOTHNESS TEST

Construct the top lift so that the surface shows no deviations exceeding the tolerances of paragraph ACCEPTANCE when tested with a 12 foot straightedge. Test the entire area in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each placement lane and at the 1/8th point in from each side of the lane. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the surface and measuring the maximum gap between the straightedge and the surface. Determine measurements along the entire length of the straight edge. Correct deviations exceeding the tolerances of Table 1 by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.12 FIELD QUALITY CONTROL

3.12.1 In-Place Tests

Perform one of each of the following [In-Place Tests](#) on samples taken from the placed and compacted rigid pavement base course. Determine sample locations using random sampling in accordance with [ASTM D3665](#). Take samples and test at the rates indicated.

- a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 500 square [yards](#), or portion thereof, of completed area.
- b. Perform gradation on every lift of material placed and at a frequency of one gradation for every 1,000 [500](#) square [yards](#), or portion thereof, of material placed.
- c. Perform liquid limit and plasticity index tests at the same frequency as the gradation.
- d. Measure the thickness of each course at intervals providing at least one measurement for each 500 square [yards](#) or part thereof. Measure the thickness using test holes, at least [3 inches](#) in diameter through the course.

3.12.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted course(s).

3.13 TRAFFIC

Completed portions of the rigid pavement base course can be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed rigid pavement base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed rigid pavement base course, protect the area against marring or damage to the completed work. Repair damage to meet these specifications.

3.14 MAINTENANCE

Maintain the completed course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area that is damaged as necessary to comply with this specification.

3.15 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land . No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 11 23

AGGREGATE BASE COURSE FOR FLEXIBLE PAVING

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2022) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C1252	(2017) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000

	ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7928	(2017) Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in [ASTM D1557](#) abbreviated as a percent of

laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the laboratory maximum dry density in accordance with ASTM D1557 Method C and corrected with ASTM D4718/D4718M.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G, R0

SD-06 Test Reports

Initial Tests; G, R0

In-Place Tests; G, R0

1.4 QUALITY ASSURANCE

Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Do not start work requiring testing until the testing laboratory has been inspected and approved. All contractor quality control testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and on-site laboratory. Validation on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at <https://mtc.erdcdren.mil/requestvalidation.aspx#> for costs and scheduling. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. Furnish copies of test results within 24 hours of completion of the tests.

1.4.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M.

1.4.2 Tests

1.4.2.1 Gradation Analysis

Perform gradation analysis in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11..

1.4.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.4.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content

in accordance with paragraph DEGREE OF COMPACTION.

1.4.2.4 Field Density Tests

Measure field density in accordance with [ASTM D1556/D1556M](#), or [ASTM D6938](#). For the method presented in [ASTM D1556/D1556M](#) use the base plate as shown in the drawing. For the method presented in [ASTM D6938](#) check the calibration curves and adjust them, if necessary, using only the sand cone method as described in Annex A2 of [ASTM D6938](#). Use [ASTM D6938](#) to determine the moisture content of the soil. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in [ASTM D6938](#). Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in Annex A2 of [ASTM D6938](#), on each different type of material being tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.4.2.5 Wear Test

Perform wear tests on ABC and GCA course material in conformance with [ASTM C131/C131M](#).

1.4.2.6 Flat and Elongated Pieces

Determine flat and elongated pieces on ABC and GCA course material in conformance with [ASTM D4791](#), Method A.

1.4.2.7 Soundness

Perform soundness tests on GCA in accordance with [ASTM C88](#).

1.4.2.8 Fractured Faces

Perform fractured faces test on ABC GCA coarse aggregate in conformance with [ASTM D5821](#). Determine uncompacted void content of the GCA fine aggregate in accordance with [ASTM C1252](#), Method A.

1.4.2.9 Weight of Slag

Determine weight per cubic foot of slag in accordance with [ASTM C29/C29M](#) on the ABC and GCA course material.

1.5 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above [35 degrees F](#). When the temperature falls below [35 degrees F](#), protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

1.6 ACCEPTANCE

1.6.1 Tolerances

Acceptance of [ABC and GCA](#) is based on compliance with the tolerances presented in Table 1. Remove any materials found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification

TABLE 1	
Measurement	Tolerance
Grade	Plus 1/4 inch, Minus 1/2 inch
Smoothness	Plus/Minus 3/8 inch
Individual Test Total Thickness	Plus/Minus
Average Job Thickness	Plus/Minus
Compaction	Minimum 100 percent

PART 2 PRODUCTS

2.1 AGGREGATES

Provide ABC and GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, angular sand, or other approved material. Provide ABC that is free of lumps of clay, organic matter, and other objectionable materials or coatings. The portion retained on the No. 4 sieve is known as coarse aggregate; that portion passing the No. 4 sieve is known as fine aggregate. When the coarse and fine aggregate is supplied from more than one source, provide aggregate from each source that meets the specified requirements.

2.1.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. Separately stockpile coarse aggregate supplied from more than one source.

- a. Crushed Gravel: Provide crushed gravel that has been manufactured by crushing gravels and that meets all the requirements specified below.
- b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.
- c. Crushed Recycled Concrete: Provide crushed recycled concrete (RCA) consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. Provide RCA of a consistent gradation and properties obtained from on-base stockpiles or concrete pavement demolished under this contract. Provide recycled concrete that is free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and that has been crushed and processed to meet the required gradations for coarse aggregate. Reject recycled concrete aggregate exceeding this value. Provide crushed recycled concrete that meets all other applicable requirements specified below.
- d. Crushed Slag: Provide crushed slag that is an air-cooled blast-furnace product having a minimum air dry unit weight of 70 pcf as determined by ASTM C29/C29M, and meets all the requirements specified below.

2.1.1.1 Aggregate Base Course

Limit the percentage of loss of ABC coarse aggregate to a maximum of 50 percent when tested in accordance with [ASTM C131/C131M](#). Provide aggregate that contains a maximum of 30 percent flat and elongated particles when tested in accordance with [ASTM D4791](#), Method A. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, provide crushed aggregates containing a minimum of 50 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with [ASTM D5821](#). When two fractures are contiguous, the angle between planes of the fractures is required to be a minimum of 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 2.

2.1.1.2 Graded-Crushed Aggregate Base Course

Limit the percentage of loss of GCA coarse aggregate to a maximum of 40 percent when tested in accordance with [ASTM C131/C131M](#). Provide GCA coarse aggregate that does not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with [ASTM C88](#). . Provide aggregate that contains a maximum of 20 percent flat and elongated particles for the fraction retained on the $\frac{1}{2}$ inch sieve nor 20 percent for the fraction passing the $\frac{1}{2}$ inch sieve when tested in accordance with [ASTM D4791](#), Method A. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, provide crushed aggregate containing a minimum of 90 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with [ASTM D5821](#). When two fractures are contiguous, the angle between planes of the fractures is required to be a minimum of 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 2.

2.1.2 Fine Aggregate

Provide fine aggregates consisting of angular particles of uniform density.

2.1.2.1 Aggregate Base Course

Provide ABC fine aggregate that consists of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.2.2 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Provide fine aggregate that contains a minimum of 45 percent by weight of uncompacted voids when tested in accordance with [ASTM C1252](#), Method A.

2.1.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course.

Provide aggregates that are continuously well graded within the limits specified in TABLE 2. Use sieves that conform to [ASTM E11](#).

TABLE 2. GRADATION OF AGGREGATES			
Percentage By Weight Passing Square-Mesh Sieve			
Sieve Designation	No. 1	No. 2	No.3
2 inch	100	---	---
1-1/2 inch	70-100	100	---
1 inch	45-80	60-100	100
1/2 inch	30-60	30-65	40-70
No. 4	20-50	20-50	20-50
No. 10	15-40	15-40	15-40
No. 40	5-25	5-25	5-25
No. 200	0-8	0-8	0-8

NOTE 1: Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with [ASTM D7928](#).

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, test the materials in accordance with [ASTM C127](#) and [ASTM C128](#) to determine their specific gravities. Correct the percentages passing the various sieves as directed if the specific gravities vary by more than 10 percent.

NOTE 3: Gradations containing more than 30 percent retained on the $\frac{3}{4}$ inch sieve can produce inconsistent compacted density values when tested in accordance with paragraph DEGREE OF COMPACTION.

2.2 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. Limit the portion of any component or of the completed course passing the No. 40 sieve to be either nonplastic or have a maximum liquid limit of 25 and a maximum plasticity index of 5.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Initial Tests

Perform one of each of the following [initial tests](#) on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements when furnished. Complete this testing for each source if materials from more than one source are proposed. Submit certified copies of test results for approval a minimum of 30 days before material is required for the work.

- Gradation Analysis .
- Liquid limit and plasticity index.

- c. Moisture-density relationship.
- d. Wear.
- e. Flat and Elongated Pieces.
- f. Soundness.
- g Fractured Faces .
- h. .
- i. .

2.3.2 Approval of Material

Tentative approval of material will be based on initial test results.

2.4 EQUIPMENT, TOOLS, AND MACHINES

All **plant, equipment, and tools** used in the performance of the work are subject to approval by the Government before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC or GCA is constructed in more than one lift, clean the previously constructed lift of loose and foreign matter by sweeping with power sweepers or power brooms. Use hand brooms in areas where power cleaning is not practicable. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Condition aggregate sources on private lands in accordance with local laws or authorities. Clear, strip, and excavate as required. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the base course(s). Do not construct base course(s) on

underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in [ASTM D2487](#), stabilize the surface prior to placement of the base course(s). Stabilize by mixing ABC or GCA into the underlying course and compacting by approved methods. Proof roll in accordance with paragraph PROOF ROLLING. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a compliant condition until the base course is placed.

3.5 GRADE CONTROL

Provide a finished and completed base course conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

3.6.1 Mixing

Mix the coarse and fine aggregates in a stationary plant. Make adjustments in mixing procedures or in equipment to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to produce a satisfactory base course meeting all requirements of this specification.

3.6.2 Placing

Place the mixed material on the prepared subgrade or subbase in lifts of uniform thickness with an approved spreader. Place the lifts so that when compacted they are true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one lift, clean the previously constructed lift of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms. Make adjustments in placing procedures or equipment to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to produce an acceptable base course.

3.7 LAYER THICKNESS

Compact the completed base course to the thickness indicated. Limit individual compacted lifts to a maximum thickness of [6 inches](#) and a minimum thickness of [3 inches](#). Compact the base course(s) to a total thickness that is within the tolerances of paragraph ACCEPTANCE of the thickness indicated. Where the measured thickness is more than [1/2 inch](#) deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than [1/2 inch](#) thicker than indicated, the course will be considered as conforming to the specified thickness requirements. However, the requirements for wearing course thickness and plan grade are still applicable. The average job thickness will be the average of all thickness measurements taken for the job and within the tolerances of

paragraph ACCEPTANCE of the thickness indicated.

3.8 COMPACTION

Compact each lift of the base course, as specified, with approved compaction equipment. For cohesive soils, maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified and for cohesionless soils, maintain the water content to facilitate compaction without bulking. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction until each lift is compacted through the full depth to meet the compaction requirements of Table 1. Make such adjustments in compacting or finishing procedures to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to produce a compliant base course. Remove any materials found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification.

3.9 EDGES OF BASE COURSE

Place the base course(s) so that the completed section is a minimum of **1 foot** wider, on all sides, than the next lift that will be placed above it.

Place approved material along the outer edges of the base course in sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more lifts, simultaneously roll and compact at least a **2 foot** width of this shoulder material with the rolling and compacting of each lift of the base course.

3.10 FINISHING

Finish the surface of the top lift of base course after final compaction by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin lifts of material to the top lift of base course to meet grade. If the elevation of the top lift of base course exceeds the tolerances of paragraph ACCEPTANCE, scarify the top lift to a depth of at least **3 inches** and blend new material in and compact to bring to grade. Make adjustments to rolling and finishing procedures to minimize segregation and degradation, obtain grades, maintain moisture content, and produce an acceptable base course. If the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the non-compliant portion and rework and recompact it or replace as directed.

3.11 SMOOTHNESS TEST

Construct the top lift so that the surface shows no deviations exceeding the tolerances of paragraph ACCEPTANCE when tested with a **12 foot** straightedge. Test the entire area in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines at a maximum spacing of **15 feet** or less apart, as directed. Perform the longitudinal lines at the centerline of each placement lane, regardless of whether multiple lanes are allowed to be paved at the same time, and at the 1/8th point in from each side of the lane. Hold the straightedge in contact with the surface and moved ahead one-half the length of the

straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Determine measurements along the entire length of the straight edge. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.12 FIELD QUALITY CONTROL

3.12.1 In-Place Tests

Perform each of the following **in-place tests** on samples taken from the placed and compacted ABC and GCA. Determine sample locations using random sampling in accordance with **ASTM D3665**. Take samples and test at the rates indicated.

- a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 **500 square yards**, or portion thereof, of completed area. Gradations containing more than 30 percent retained on the **3/4 inch** sieve can produce inconsistent compacted density values when tested in accordance with paragraph DEGREE OF COMPACTION.
- b. Perform gradation analysis on every lift of material placed and at a frequency of one sieve analysis for every 500 **1000 square yards**, or portion thereof, of material placed.
- c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.
- d. Measure the thickness of the base course at intervals providing at least one measurement for each 500 **1000 square yards** of base course or part thereof. Measure the thickness using test holes, at least **3 inch** in diameter through the base course.

3.12.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted course(s).

3.13 TRAFFIC

Completed portions of the base course can be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed base course, protect the area against marring or damage to the completed work. Repair damage to meet these specifications.

3.14 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any base course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area of base course that is damaged

as necessary to comply with this specification.

3.15 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land . No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 12 13

BITUMINOUS TACK AND PRIME COATS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO T 102 (2009; R 2013) Standard Method of Test for
Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM D140/D140M (2016) Standard Practice for Sampling
Asphalt Materials

ASTM D977 (2019a; E 2019) Standard Specification for
Emulsified Asphalt

ASTM D2027/D2027M (2019) Cutback Asphalt (Medium-Curing Type)

ASTM D2028/D2028M (2015) Cutback Asphalt (Rapid-Curing Type)

ASTM D2397/D2397M (2019a) Standard Specification for
Cationic Emulsified Asphalt

ASTM D2995 (1999; R 2009) Determining Application
Rate of Bituminous Distributors

ASTM D6373 (2016) Standard Specification for
Performance Graded Asphalt Binder

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED BD+C (2009; R 2010) Leadership in Energy and
Environmental Design(tm) Building Design
and Construction (LEED-NC)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section **01 33 00** SUBMITTAL PROCEDURES:

SD-03 Product Data

Local/Regional Materials

SD-06 Test Reports

Sampling and Testing

1.3 QUALITY ASSURANCE

Certificates of compliance for asphalt materials delivered will be obtained and checked to ensure that specification requirements are met. Quantities of applied material will be determined. Payment will be for amount of residual asphalt applied. Tack coat materials will not be diluted. Prime coat materials when emulsions are used can be diluted on site with potable water up to 1 part emulsion to 1 part water.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.5 EQUIPMENT, TOOLS AND MACHINES

1.5.1 General Requirements

Equipment, tools and machines used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Calibrate equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment within 12 months of their use. If the calibration expires during project, recalibrate the equipment before work can continue.

1.5.2 Bituminous Distributor

Provide a self propelled distributor with pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the surface being sprayed. Calibrate the distributor in accordance with [ASTM D2995](#). Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled total liquid rates from [0.03 to 1.0 gallons per square yard](#), with a pressure range of [25 to 75 psi](#) and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor will be capable of circulating and agitating the bituminous material during the heating process.

1.5.3 Heating Equipment for Storage Tanks

Use steam, electric, or hot oil heaters for heating the bituminous material. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot come in contact with the bituminous material. Fix an armored thermometer to the tank with a temperature range from [40 to 400 degrees F](#) so that the temperature of the bituminous material may be determined at all times.

1.5.4 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.6 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. A limited amount of moisture (approximately 0.03 gallon/square yard) can be sprayed on the surface of unbound material when prime coat is used to improve coverage and penetration of asphalt material. Apply bituminous coat only when the atmospheric temperature in the shade is 50 degrees F or above and when the temperature has not been below 35 degrees F for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PRIME COAT

Provide asphalt conforming to one of the following grades:

2.1.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2027/D2027M, Grade MC-30, MC-70, or MC-250 ASTM D2028/D2028M, Grade RC-70 or RC-250.

2.2 TACK COAT

2.2.1 Asphalt Cement

Provide asphalt cement conforming to or ASTM D6373 Grade 67-22.

2.2.2 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2028/D2028M, Grade RC-70 or RC-250.

2.2.3 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS1h ASTM D2397/D2397M, Type CSS-1h. For prime coats the emulsified asphalt can be diluted with up to 1 part emulsion to 1 part water. No dilution is allowed for tack coat applications. The base asphalt used to manufacture the emulsion is required to show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

2.2.4 Local/Regional Materials

Use Local/Regional Materials or products extracted, harvested, or recovered, as well as manufactured, within a 500 mile radius from the project site, if available from a minimum of three sources. See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for cumulative total local material requirements. Tack and prime coat materials may be locally available. Submit documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project in accordance with LEED BD+C.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. Apply treatment only when the surface is dry and clean.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities of not less than **0.03 gallons** nor more than **0.10 gallons per square yard** of residual asphalt onto the pavement surface as approved by the Contracting Officer. Do not dilute asphalt emulsion when used as a tack coat.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than **0.05 gallons** nor more than **0.12 gallons per square yard** of residual asphalt for asphalt emulsion up to a 1 to 1 dilution rate or for residual asphalt for cutback asphalt.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Apply asphalt at a temperature that will provide a viscosity between 10 and 60 seconds, Saybolt Furol, or between **20 and 120 centistokes**, kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

Cutback Asphalts	
MC-30	85-190 degrees F
SC-70, MC-70, RC-70	120-225 degrees F
SC-250, MC-250, RC-250	165-270 degrees F
Asphalt Emulsion	
All Grades	70-160 degrees F

Cutback Asphalts	
Asphalt Cement	
All Grades	275-350 degrees F

Some of these temperatures for rapid cure cutbacks are above the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the bituminous distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots, not capable of being sprayed with the distributor, with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of cutback materials. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat requirements are described herein.

3.4.2 Prime Coat

Apply a prime coat at locations shown on the Drawings. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate will be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings. A tack coat should be applied to every bound surface (asphalt or concrete pavement) that is being overlaid with asphalt mixture and at transverse and longitudinal joints. Apply the tack coat when the surface to be treated is clean and dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor by spraying with a hand wand or using other approved method. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as

far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of asphalt mixture allow the bituminous coat to cure and water or volatiles to evaporate prior to overlaying. Maintain the tacked surface in good condition until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up excess bituminous material.

3.6 FIELD QUALITY CONTROL

Obtain certificates of compliance for all asphalt material delivered to the project. Obtain samples of the bituminous material under the supervision of the Contracting Officer. The sample may be retained and tested by the Government at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt or asphalt cement, compliance with applicable specified requirements, not less than 5 days before the material is required in the work.

3.7.1 Sampling

Unless otherwise specified, sample bituminous material in accordance with [ASTM D140/D140M](#).

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibrate using the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with [ASTM D2995](#).

3.7.3 Trial Applications

Before applying the spray application of tack or prime coat, apply three lengths of at least [100 feet](#) for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of [0.05 gallons per square yard](#). Make other trial applications using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of

bituminous materials in the amount of 0.15 gallon per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --

SECTION 32 12 16.16

ROAD-MIX ASPHALT PAVING

PART 1 GENERAL

1.1 PAYMENT

1.1.1 Method of Measurement

Measurement of the quantity of hot-mix asphalt pavement per lot will be made for the purposes of assessing acceptance stipulated in paragraph ACCEPTANCE.

1.1.2 Basis of Payment

The measured quantity of hot-mixed asphalt pavement will be paid for and included in the lump sum contract price.

1.2 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 156	(2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO T 304	(2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate
AASHTO T 329	(2015) Standard Test Method for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

ASPHALT INSTITUTE (AI)

AI MS-2	(2015) Asphalt Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

ASTM C128	(2022) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D979/D979M	(2015) Sampling Bituminous Paving Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3203/D3203M	(2017) Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles

	in Coarse Aggregate
ASTM D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5361/D5361M	(2016) Standard Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6084/D6084M	(2018) Standard Test Method for Elastic Recovery of Asphalt Materials by Ductilometer
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyrotory Compactor
ASTM E1274	(2018) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Placement Plan; G, R0

SD-03 Product Data

Diamond Grinding Plan; G, R0

Mix Design; G, R0

Contractor Quality Control; G, R0

SD-04 Samples

Aggregates

Asphalt Cement Binder

SD-06 Test Reports

Aggregates; G, R0

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G, R0

Laboratory Accreditation and Validation

1.4 ACCEPTANCE

1.4.1 Acceptability of Work

Acquire the services of an independent commercial laboratory to perform acceptance testing. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests from split samples to validate the results of the production testing. Testing performed by the Government does not reduce the required testing of the independent commercial laboratory. Split samples will be taken for Government testing to reduce the variability between the independent commercial laboratory and the Government's test results. When the difference between the independent commercial laboratory and the Government's test results for split samples exceed the acceptable range of two results for multilaboratory precision for the appropriate test method (i.e. ASTM) then at least one of the laboratories is determined to be in error. An evaluation of procedures and equipment in both laboratories will be made to determine the cause(s) for the differences. Develop steps to correct procedures and equipment to bring multilaboratory precision to within acceptable limits.

1.4.2 Acceptance Requirements

Provide all sampling and testing required for acceptance. Where appropriate, **acceptance** for individual lots of asphalt pavement will be made based on laboratory air voids, in-place density, smoothness, and grade in accordance with the following paragraphs. Surface smoothness and grade determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus smoothness and grade measurements for the entire lot cannot be made.

1.4.3 Pavement Lots

A standard lot for all requirements is equal to one day's production or 2,000 tons, whichever is smaller. Divide each lot into four equal sublots in order to evaluate laboratory air voids and in-place density. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot and the total number of sublots (i.e. 5 or 6 sublots) is used for acceptance criteria. Include partial lots at the end of asphalt production into the previous lot. Complete and report all theoretical maximum density, laboratory air voids,

and in-place density testing within 24 hours after construction of each lot.

1.4.4 Sublot Sampling

Take one mixture sample for each subplot in accordance with [ASTM D979/D979M](#) from a random truck or another location for determining theoretical maximum density, laboratory air voids, any additional testing the Government desires, and Contractor Quality Control. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to [ASTM D3665](#) and employing tables of random numbers or computer programs.

1.4.5 Additional Sampling and Testing

The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be treated as a separate lot. [Acceptance](#) will be made for the quantity of asphalt pavement represented by these tests in accordance with the provisions of this section.

1.4.6 Theoretical Maximum Density (TMD)

Measure theoretical maximum density one time for each subplot in accordance with [ASTM D2041/D2041M](#) for purposes of calculating laboratory air voids and determining in-place density. The average TMD for each lot will be determined as the average TMD of the random subplot samples. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD values will be used as the TMD needed to calculate the percent joint density.

1.4.7 Laboratory Air Voids

[Prepare one set of laboratory compacted specimens for each subplot in accordance with \[ASTM D6925\]\(#\) using the Superpave gyratory compactor.](#) Provide three test specimens prepared from the same sample for each set of laboratory compacted specimens. Compact the specimens within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Do not reheat samples prior to compaction. Provide insulated containers as necessary to maintain the sample temperature. Measure the bulk density of laboratory compacted specimens in accordance with [ASTM D2726/D2726M](#). Determine laboratory air voids from one set (three laboratory compacted specimens) for each subplot sample in accordance with [ASTM D3203/D3203M](#).

1.4.7.1 Tolerance

[Provide laboratory air voids with a mean absolute deviation of 1.00 percent or less from the JMF for each lot. Remove and replace lots that do not meet the laboratory air voids requirement at least 4 inches into the cold \(existing\) lane adjacent to the longitudinal joint, at no additional cost to the Government. The mean absolute deviation of the laboratory air void contents from the JMF air void content will be evaluated as shown in the example below.](#)

1.4.7.2 Calculating Laboratory Air Voids

[Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. Determine the](#)

average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). The mean absolute deviation of the laboratory air void contents (one from each subplot) from the JMF air void content will be evaluated as in the following example:

Assume that the laboratory air voids are determined from 4 sublots where one set of laboratory compacted specimens is from a single subplot. The laboratory air voids for the 4 sublots are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

$$\text{Mean Absolute Deviation} = (|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|)/4$$

$$\text{Mean Absolute Deviation} = (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45$$

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen that 0.45 is less than 1.00 percent. The lot is acceptable for laboratory air voids.

1.4.8 In-place Density

Obtain one random 4 inch or 6 inch diameter core from the mat and joint of each subplot in accordance with ASTM D5361/D5361M for determining in-place density. Cut samples neatly with a diamond core drill bit. Obtain random cores that are the full thickness of the layer being placed. Select core locations randomly using the procedures contained in ASTM D3665. Locate cores for mat density no closer than 12 inches from a transverse or longitudinal joint including the pavement edge. Center all cores for joint density on the joint. Discard samples that are clearly defective as a result of sampling and take an additional random core. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, obtain another random core sample. Clean and tack coat dry core holes before filling with asphalt mixture. Fill all core holes with asphalt mixture and compact using a standard Marshall hammer to the density specified. Provide all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Measure in-place density in accordance with ASTM D2726/D2726M using each core obtained from the mat and joint.

1.4.8.1 Tolerance

Provide a minimum in-place mat density of 93.0 percent and a minimum in-place joint density of 90.0 percent for each lot. The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. Determine the average TMD in accordance with paragraph THEORETICAL MAXIMUM DENSITY (TMD). Remove and replace lots that do not meet the in-place mat density requirement at least 4 inches into the cold (existing) lane adjacent to the longitudinal joint, at no additional cost to the Government. Remove and replace the longitudinal joint when the lot does not meet the in-place joint density, at no additional cost to the Government. Use a 10 feet wide paving lane that is centered over the joint.

1.4.9 Surface Smoothness

Use a straightedge and profilograph for measuring surface smoothness. Use the profilograph method for all longitudinal testing, except for paving lanes less than 0.25 miles in length. Use the straightedge method for

transverse testing, for longitudinal testing where the length of each pavement lane is less than 0.25 miles, and at the ends of the paving limits for the project. Smoothness requirements do not apply over crowns or grade breaks. Maintain detailed notes of the testing results and provide a copy to the Government immediately after each day's testing.

1.4.9.1 Smoothness Requirements

1.4.9.1.1 Straightedge Testing

Provide finished surfaces of the pavements with no abrupt change of 1/4 inch or more when checked with an approved 12 foot straightedge. Remove and replace surface lift lots when the surface smoothness exceeds 3/8 inch, at no additional cost to the Government. High spots can be diamond ground as an alternative to remove and replace in order to meet surface smoothness requirements at individual locations.

1.4.9.1.2 Profilograph Testing

Provide finished surfaces with a Profile Index not greater than 9 inches per mile when tested with an approved California-type profilograph. Remove and replace the lot when the Profile Index exceeds the tolerance by 4.0 inches per mile or more, at no additional cost to the Government. Correct any small individual area with surface deviation which exceeds the tolerance given above by more than 5.0 inches per mile or more by diamond grinding to meet the specification requirements above or remove and replace at no additional cost to the Government.

1.4.9.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in a manner to reveal surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding. The maximum area allowed to be corrected by diamond grinding is 10 percent of the total area of the lot. Test the entire area of the pavement with a profilograph. Check a number of random locations along with any observed suspicious locations primarily at transverse and longitudinal joints with the straightedge.

1.4.9.2.1 Straightedge Testing

Use the straightedge to measure abrupt changes in surface smoothness. Hold the straightedge in contact with the pavement surface and measure the maximum distance between the straightedge and the pavement surface. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

1.4.9.2.2 Profilograph Testing

Perform profilograph testing using an approved California profilograph and procedures described in ASTM E1274. Provide equipment that utilizes electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for the pavement. Use a "blanking band" that is 0.2 inch wide and the "bump template" spanning 1 inch with an offset of 0.4 inch. Provide profilograph operated by an

approved, factory-trained operator on the alignments specified above. Provide a copy of the reduced tapes to the Government at the end of each day's testing.

1.4.9.2.3 Bumps ("Must Grind" Areas)

Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding until they do not exceed 0.3 inch when retested. Taper diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. At the Contractor's option, pavement areas including diamond ground areas can be rechecked with the profilograph in order to record a lower Profile Index. Perform additional profilograph testing in all areas corrected by diamond grinding.

1.4.10 Plan Grade

Provide a final wearing surface of pavement conforming to the elevations and cross sections shown and not vary more than 0.05 foot from the plan grade established and approved at site of work. Within 5 working days after completion of a particular lot incorporating the final wearing course, test the final wearing surface of the pavement for conformance with specified plan grade requirements. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. For roads, the grade will be determined by running lines of levels along the centerline at intervals of 25 feet or less longitudinally to determine the elevation of the completed pavement surface. Measure transverse grades at appropriate intervals. For parking lots, the grade will be determined by running lines of levels at intervals of 25 feet or less longitudinally and transversely to determine the elevation of the completed pavement surface. Diamond grinding can be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted. Maintain detailed notes of the results of the testing and provide a copy to the Government immediately after each day's testing.

Remove and replace surface lift lots when individual locations exceed 0.05 foot tolerance, at no additional cost to the Government. High spots can be diamond ground as an alternative to remove and replace in order to meet plan grade requirements at individual locations.

1.4.11 Laboratory Accreditation and Validation

Provide laboratories used to develop the Job Mix Formula (JMF), perform acceptance testing, and Contractor Quality Control testing that meet the requirements of ASTM D3666. Provide laboratories with a masonry saw having a diamond blade for trimming pavement cores and samples. Perform all required test methods by an accredited laboratory. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory accreditation is not allowed. The Government will inspect the laboratory equipment and test procedures prior to the start of hot-mix operations for conformance with ASTM D3666. In addition, all testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and plant testing laboratory. Validation

on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at <https://mtc.erdc.dren.mil> for costs and scheduling. Submit a certificate of compliance signed by the manager of the laboratory stating that it meets these requirements to the Government prior to the start of construction. At a minimum, include the following certifications:

- a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.
- b. A listing of equipment to be used in developing the job mix.
- c. A copy of the laboratory's quality control system.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not place the asphalt mixture upon a wet surface or when the surface temperature of the underlying course is less than specified in [Table 1](#). The temperature requirements may be waived by the Government, if requested; however, meet all other requirements including compaction.

Table 1 . Surface Temperature Limitations of Underlying Course	
Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Provide asphalt pavement designed and constructed in accordance with this section conforming to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course. Submit proposed [Placement Plan](#) indicating lane widths and longitudinal joints for each course or lift.

2.1.1 Asphalt Mixing Plant

Provide plants used for the preparation of asphalt mixture conforming to the requirements of [AASHTO M 156](#) with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved scales, or on certified public scales at no additional expense to the Government. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Inspection of Plant

Provide access to the Government at all times, to all areas of the plant

for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.1.1.3 Storage bins

The asphalt mixture can be stored in non-insulated storage bins for a period of time not exceeding 3 hours. The asphalt mixture can be stored in insulated storage bins for a period of time not exceeding 8 hours. Provide the mix drawn from bins that meets the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks used for hauling asphalt mixture that have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a minimum amount of paraffin oil, lime solution, or other approved material. Do not use petroleum based products as a release agent. Provide each truck with a suitable cover to protect the mixture from adverse weather, contamination, and loss of material during hauling. When necessary due to long haul distance and cold weather, provide insulated truck beds with covers (tarps) that are securely fastened.

2.1.3 Asphalt Pavers

Provide mechanical spreading and finishing equipment consisting of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. Provide paver screed capable of laying a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed. Provide a paver with a vibrating screed to be used during all placement.

2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and a distribution system to place the mixture uniformly in front of the screed without segregation. Provide a screed that effectively produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.4 Rollers

Provide rollers in good condition and operate at slow speeds to avoid displacement of the asphalt mixture. Provide sufficient number, type, and weight of rollers to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.1.5 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the asphalt pavement with approved

equipment. Perform diamond grinding by sawing with saw blades impregnated with an industrial diamond abrasive. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the asphalt pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 feet wide. Diamond grinding equipment that causes raveling, fracturing of aggregate, or disturbance to the underlying material will not be allowed. The maximum area corrected by diamond grinding the surface of the asphalt pavement is 10 percent of the total area of any lot. The maximum depth of diamond grinding is 1/2 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified.

Prior to production diamond grinding operations, perform a test section at the approved location, consisting of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish and transition between adjacent passes. Production diamond grinding operations cannot be performed prior to approval.

2.2 AGGREGATES

Notify the Government at least 7 days before sampling aggregates. Obtain samples in accordance with ASTM D75/D75M that are representative of the materials to be used for the project. Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand, and mineral filler as required. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit sufficient materials to produce 200 pounds of blended mixture for mix design verification. Submit all aggregate test results and samples to the Government at least 14 days prior to start of construction. Perform job aggregate testing no earlier than 6 months before contract award.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. Provide coarse aggregate particles meeting the following requirements:

- a. The percentage of loss not greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.
- c. At least 75 percent by weight of coarse aggregate containing two or more fractured faces when tested in accordance with ASTM D5821 with fractured faces produced by crushing.
- d. The particle shape essentially cubical and the aggregate containing not more than 10 percent, by weight, of flat and elongated particles (5:1 ratio of length to thickness) when tested in accordance with

ASTM D4791, Method B.

- e. Slag consisting of air-cooled, blast furnace slag with a compacted weight of not less than 75 lb/cu ft when tested in accordance with ASTM C29/C29M.
- f. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.2 Fine Aggregate

Provide fine aggregate consisting of clean, sound, tough, durable particles. Provide aggregate particles that are free from coatings of clay, silt, or any objectionable material, contain no clay balls, and meet the following requirements:

- a. Quantity of natural sand (noncrushed material) added to the aggregate blend not exceeding 15 percent by weight of total aggregate.
- b. Individual fine aggregate sources with a sand equivalent value greater than 45 when tested in accordance with ASTM D2419.
- c. Fine aggregate portion of the blended aggregate with an uncompacted void content greater than 45.0 percent when tested in accordance with AASHTO T 304 Method A.
- d. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.3 Mineral Filler

Provide mineral filler consisting of a nonplastic material meeting the requirements of ASTM D242/D242M.

2.2.4 Aggregate Gradation

Provide a combined aggregate gradation that conforms to gradations specified in Table 2, when tested in accordance with ASTM C136/C136M and ASTM C117, and does not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grades uniformly from coarse to fine. Provide a JMF within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 4 and 5 are applied.

Table 2. Aggregate Gradations	
Sieve Size, inch	Gradation 2 Percent Passing by Mass
1	---
3/4	100
1/2	90-100
3/8	69-89
No. 4	53-73
No. 8	38-60

Table 2. Aggregate Gradations	
Sieve Size, inch	Gradation 2 Percent Passing by Mass
No. 16	26-48
No. 30	18-38
No. 50	11-27
No. 100	6-18
No. 200	3-6

2.3 ASPHALT CEMENT BINDER

Provide asphalt cement binder that conforms to Performance Grade (PG) 67-22.. Provide an asphalt binder with a minimum elastic recovery of 75 percent in accordance with ASTM D6084/D6084M. Provide test data indicating grade certification by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Government. The supplier is defined as the last source of any modification to the binder. The Government may sample and test the binder at the mix plant at any time before or during mix production. Submit 5 gallon sample of the asphalt cement or asphalt binder not less than 14 days before start of the test section for mix design verification and approval. Obtain samples for this verification testing in accordance with ASTM D140/D140M and in the presence of the Government. Provide these samples to the Government for the verification testing, which will be performed at the Government's expense.

2.4 MIX DESIGN

Develop the mix design in accordance with Georgia DOT Superpave 9.5mm and 12.5mm mixtures. Perform Job Mix formula (JMF) and aggregates testing no earlier than 6 months before contract award. Provide asphalt mixture composed of well-graded aggregate, mineral filler if required, and asphalt material. Provide aggregate fractions sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 2. Do not produce asphalt pavement for acceptance until a JMF has been approved. Design the asphalt mixture using the Superpave gyratory compactor set at 75 gyrations for roadways and 50 gyrations for parking lots. Prepare samples at various asphalt contents and compacted in accordance with ASTM D6925. Use laboratory compaction temperatures for Polymer Modified Asphalts as recommended by the asphalt binder manufacturer. Determine the Tensile Strength Ratio (TSR) of the composite mixture in accordance with ASTM D4867/D4867M. Compact the TSR specimens to an air void content of 7 percent plus or minus 1 percent. If the Tensile Strength Ratio (TSR) of the composite mixture is less than 75, reject the aggregates or treat the asphalt mixture with an anti-stripping agent. Add a sufficient amount of anti-stripping agent to produce a TSR of not less than 75. If an antistrip agent is required, provide it at no additional cost to the Government. Provide sufficient materials to produce 200 pound of blended mixture to the Government for verification of mix design at least 14 days

prior to construction of test section.

2.4.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section including, as a minimum:

- a. Percent passing each sieve size.
- b. Percent of asphalt cement.
- c. Percent of each aggregate and mineral filler to be used.
- d. Asphalt performance grade or penetration grade.
- e. Number of Superpave gyratory compactor gyrations.
- f. Laboratory mixing temperature.
- g. Laboratory compaction temperature.
- h. Temperature-viscosity relationship of the asphalt cement
- i. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.
- j. Graphical plots and summary tabulation of air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Include summary tabulation that includes individual specimen data for each specimen tested.
- k. Specific gravity and absorption of each aggregate.
- l. Percent natural sand.
- m. Percent particles with two or more fractured faces (in coarse aggregate).
- n. Fine aggregate angularity.
- o. Percent flat or elongated particles in coarse aggregate.
- p. Tensile Strength Ratio and wet/dry specimen test results.
- q. Antistrip agent (if required).
- r. List of all modifiers.
- s. Percentage and properties (asphalt content, aggregate gradation, and aggregate properties) of RAP in accordance with paragraph RECYCLED ASPHALT PAVEMENT, if RAP is used.

Table 3. Mix Design Criteria	
Test Property	Superpave (50, 75 gyrations)
Stability, pounds, minimum (NA for Superpave)	NA
Flow, 0.01 inch, (NA for Superpave)	NA
Air voids, percent	3-5
Minimum Percent Voids in Mineral Aggregate (VMA) ⁽²⁾	
Gradation 1	13.0
Gradation 2	14.0
Gradation 3	15.0
TSR, minimum percent	75
(1) This is a minimum requirement. Provide significantly higher average during construction to ensure compliance with the specifications.	
(2) Calculate VMA in accordance with AI MS-2, based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate.	

2.4.2 Adjustments to JMF

The JMF for each mixture is in effect until a new formula is approved in writing by the Government. Should a change in sources of any materials be made, perform a new mix design and a new JMF approved before the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve and No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the Quality Control Plan. Do not produce hot-mix asphalt for acceptance until the quality control plan has been approved. In the quality control plan, address all elements which affect the quality of the pavement including, but not limited to:

- a. Mix Design and unique JMF identification code

- b. Aggregate Grading
- c. Quality of Materials
- d. Stockpile Management and procedures to prevent contamination
- e. Proportioning
- f. Mixing and Transportation
- g. Mixture Volumetrics
- h. Moisture Content of Mixtures
- i. Placing and Compaction
- j. Joints
- k. Surface Smoothness
- l. Truck bed release agent

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site that is equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Provide laboratory facilities that are kept clean and all equipment maintained in proper working condition. Provide the Government with unrestricted access to inspect the laboratory facility, to witness quality control activities, and to perform any check testing desired. The Government will advise in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, immediately suspend the incorporation of the materials into the work. Incorporation of the materials into the work will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. Use the independent commercial laboratory for acceptance testing in paragraph ACCEPTANCE. Use in-house capabilities or the independent commercial laboratory for quality control testing. Required elements of the testing program include, but are not limited to tests for the control of asphalt content, aggregate gradation, aggregate moisture, moisture in the asphalt mixture, temperatures, VMA, and in-place density. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.1.3.1 Asphalt Content

Determine asphalt content a minimum of twice per lot (a lot is defined in paragraph PAVEMENT LOTS) using the ignition method in accordance with ASTM D6307. Use the extraction method in accordance with ASTM D2172/D2172M if the correction factor for the ignition method in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging

the test results.

3.1.3.2 Aggregate Properties

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with [ASTM D5444](#), [ASTM C136/C136M](#), and [ASTM C117](#). Determine the specific gravity of each aggregate size grouping for each [20,000 tons](#) in accordance with [ASTM C127](#) or [ASTM C128](#). Determine fractured faces for gravel sources for each [20,000 tons](#) in accordance with [ASTM D5821](#). Determine the uncompacted void content of natural sand, manufactured sand, and blended aggregate for each [20,000 tons](#) in accordance with [AASHTO T 304](#) Method A.

3.1.3.3 Moisture Content of Aggregate

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with [ASTM C566](#).

3.1.3.4 Moisture Content of Asphalt Mixture

Determine the moisture content of the asphalt mixture at least once per lot in accordance with [AASHTO T 329](#).

3.1.3.5 Temperatures

Check temperatures at least four times per lot, at necessary locations to determine the temperature at the dryer, the asphalt cement binder in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.1.3.6 VMA

Obtain mixture samples at least four times per lot. Calculate the VMA of each specimen in accordance with [AI MS-2](#) based on [ASTM C127](#) and [ASTM C128](#) bulk specific gravity for the aggregate. Provide VMA within the limits of [Table 3](#).

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device can be used to monitor pavement density.

3.1.3.8 Additional Testing

Perform any additional testing deemed necessary to control the process.

3.1.3.9 QC Monitoring

Submit all QC test results to the Government on a daily basis as the tests are performed. The Government reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Sampling

When directed by the Government, sample and test any material which appears to not meet specification requirements unless such material is voluntarily removed and replaced or deficiencies corrected. Perform all

sampling in accordance with standard procedures specified.

3.1.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 4, as a minimum. Post the control charts as directed by the Government and maintain current at all times. Identify the following on the control charts: the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 4 applicable to the test parameter being plotted, and the test results. Also show target values (JMF) on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. When the Suspension Limit is exceeded for individual values or running average values, the Government has the option to require removal and replacement of the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. In the Quality Control Plan, indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 4. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
Parameter to be Plotted	Individual Samples		Running Average of	
	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	1.4	2.0	1.1	1.5
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Stability, pounds (minimum) (NA for Superpave)				
75 Blow JMF	1800	1700	1900	1800
50 Blow JMF	1000	900	1100	1000
Flow, 0.01 inch (NA for Superpave)				
75 Blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.

Table 4. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
Parameter to be Plotted	Individual Samples		Running Average of	
	Action Limit	Suspension Limit	Action Limit	Suspension Limit
50 Blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used for acceptance			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used for acceptance			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used for acceptance			
VMA				
Gradation 1	13.5	13.0	13.3	13.0
Gradation 2	14.5	14.0	14.3	14.0
Gradation 3	15.5	15.0	15.3	15.0

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material while avoiding local overheating. Provide a continuous supply of the asphalt material to the mixer at a uniform temperature. Maintain the temperature of the asphalt delivered to the mixer to provide a suitable viscosity for adequate coating of the aggregate particles. For hot-mix, do not heat unmodified asphalt to a temperature exceeding 325 degrees F when added to the aggregate. Do not heat modified asphalt to a temperature exceeding 350 degrees F when added to the aggregate.

3.3 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate prior to mixing. Provide a rate of heating and a maximum temperature that does not damage the aggregates. Do not heat the aggregate to a temperature exceeding 350 degrees F when the asphalt binder is added. Maintain the temperature no lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF ASPHALT MIXTURE

Weigh or meter the aggregates and the asphalt cement and introduce into the mixer the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. The moisture content of all asphalt mixture upon discharge from the plant is not to exceed 0.5 percent by total weight of mixture as measured by AASHTO T 329.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the asphalt mixture, clean the underlying

course of dust and debris. Apply a prime coat or tack coat in accordance with Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.6 TRANSPORTING AND PLACING

3.6.1 Transporting

Transport asphalt mixture from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F.

3.6.2 Placing

Place the mix in lifts of adequate thickness and compact at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; strike off in a uniform layer of such depth that, when the work is completed, the required thickness is obtained and the surface conforms to the grade and contour indicated. Do not broadcast waste mixture onto the mat or recycle into the paver hopper. Collect waste mixture and dispose off site. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. Offset the longitudinal joint in one course from the longitudinal joint in the course immediately below by at least 1 foot; however, locate the joint in the surface course at the centerline of the pavement. Offset transverse joints in one course by at least 10 feet from transverse joints in the previous course. Offset transverse joints in adjacent lanes a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture can be spread and luted by hand tools.

3.7 COMPACTION OF MIXTURE

3.7.1 General

- a. After placing, thoroughly and uniformly compact the mixture by rolling. Compact the surface as soon as possible without causing displacement, cracking, or shoving. Determine the sequence of rolling operations and the type of rollers used with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. Maintain the speed of the roller, at all times, sufficiently slow to avoid displacement of the asphalt mixture and to be effective in compaction. Correct at once any displacement occurring as a result of reversing the direction of the roller, or from any other cause.
- b. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened, but excessive water is not permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers or small compactors. Remove the full depth of any mixture

that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective. Replace with fresh asphalt mixture and immediately compact to conform to the surrounding area. Perform this work at no expense to the Government. Skin patching is not allowed.

3.7.2 Segregation

The Government can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Government has the option to sample the material and have it tested and compared to the in-place density requirements in [paragraph ACCEPTANCE](#). If the material fails to meet these specification requirements, remove and replace the extent of the segregated material the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.8 JOINTS

Construct joints to ensure a continuous bond between the courses and to obtain the required density. Provide all joints with the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.8.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, construct by means of placing a bulkhead or by tapering the course. Utilize a dry saw cut on the transverse joint full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. Remove the cutback material from the project. In both methods, provide a light tack coat of asphalt material to all contact surfaces before placing any fresh mixture against the joint.

3.8.2 Longitudinal Joints

Provide a joint that meets density and smoothness requirements for joints and has uniform texture. Cut back longitudinal joints which are irregular, damaged, uncompacted, cold (less than [175 degrees F](#) at the time of placing adjacent lanes), or otherwise defective, a maximum of [3 inches](#) from the top of the course with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. Remove all cutback material from the project. Provide a light tack coat of asphalt material to all contact surfaces prior to placing any fresh mixture against the joint.

-- End of Section --

SECTION 32 13 14.13

CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 182 (2005; R 2017) Standard Specification for
Burlap Cloth Made from Jute or Kenaf and
Cotton Mats

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 201.1R (2008) Guide for Conducting a Visual
Inspection of Concrete in Service

ACI 211.1 (1991; R 2009) Standard Practice for
Selecting Proportions for Normal,
Heavyweight and Mass Concrete

ACI 214R (2011) Evaluation of Strength Test Results
of Concrete

ACI 305R (2020) Guide to Hot Weather Concreting

ACI 306R (2016) Guide to Cold Weather Concreting

ACI 325.14R (2017) Guide for Design and Proportioning
of Concrete Mixtures for Pavements

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M (2019) Standard Specification for Welded
Deformed Steel Bar Mats for Concrete
Reinforcement

ASTM A615/A615M (2022) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement

ASTM A996/A996M (2016) Standard Specification for
Rail-Steel and Axle-Steel Deformed Bars
for Concrete Reinforcement

ASTM A1064/A1064M (2022) Standard Specification for
Carbon-Steel Wire and Welded Wire
Reinforcement, Plain and Deformed, for
Concrete

ASTM A1078/A1078M	(2019) Standard Specification for Epoxy-Coated Steel Dowels in Concrete Pavement
ASTM C31/C31M	(2023) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2023) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2023) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C78/C78M	(2022) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C94/C94M	(2023) Standard Specification for Ready-Mixed Concrete
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2014) Standard Test Method for Lightweight Particles in Aggregate
ASTM C125	(2021a) Standard Terminology Relating to Concrete and Concrete Aggregates
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2023) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C174/C174M	(2017) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192/C192M	(2019) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C294	(2012; R 2017) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C295/C295M	(2019) Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494/C494M	(2019; E 2022) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2023) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2015) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C685/C685M	(2017) Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989/C989M	(2024) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1064/C1064M	(2017) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1260	(2021) Standard Test Method for Potential

Alkali Reactivity of Aggregates
(Mortar-Bar Method)

ASTM C1567	(2023) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1646/C1646M	(2016) Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing
ASTM C1895	(2020) Standard Test Method for Determination of Mohs Scratch Hardness
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2015) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 662	(2009) Determining the Potential Alkali-Silica Reactivity of Combinations

of Cementitious Materials, Lithium Nitrate
Admixture and Aggregate (Accelerated
Mortar-Bar Method)

U.S. DEPARTMENT OF DEFENSE (DOD)

TSPWG M 3-250-04.97-05

(2019) Proportioning Concrete Mixtures
with Graded Aggregates for Rigid Airfield
Pavements

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Proposed Techniques; G, R0

SD-03 Product Data

Diamond Grinding Plan; G

Dowels; G

Dowel Bar Assemblies; G

Equipment; GConcrete Patching Mixture; G

SD-05 Design Data

Proportioning Studies; G, R0

Preliminary Proposed Proportioning; G, R0

SD-06 Test Reports

Sampling and Testing; G

Diamond Grinding of PCC Surfaces; G

Mixer Performance (Uniformity) Testing; G

Repair Recommendations Plan; GPaving Lot Report; G

SD-07 CertificatesContractor Quality Control (CQC) Staff; G

NRMCA Certificate of Conformance; G, R0Petrographer Resume; G, R0

Licensed Surveyor; G, R0

Concrete Batch Plant Operator; G, R0

1.3 QUALITY CONTROL

1.3.1 Contractor Quality Control (CQC) Staff

Reference Section 01 45 00.00 10 QUALITY CONTROL QUALITY CONTROL for general CQC personnel qualification requirements. In addition, submit specific CQC personnel qualification requirements listed below. Submit qualifications and resumes for the Concrete Paving CQC Manager and petrographer. Submit certification for all CQC personnel assigned to concrete construction for their respective position:

- a. Identify an individual within the onsite work organization as the Concrete Paving CQC Manager, who is responsible for overall management of concrete paving CQC and has the authority to act in all concrete paving CQC matters including authority to stop concrete paving work which is out of compliance.

The minimum requirements for the Concrete Paving CQC Manager consist of 5 years concrete paving experience similar to work required under this contract with a minimum of 2 years in a concrete paving CQC role. The Concrete Paving CQC Manager can also serve as the CQC System Manager provided they meet the requirements of Section 01 45 00.00 10 QUALITY CONTROL and the Concrete Paving CQC Manager experience requirements above.

- b. CQC staff is required to oversee all aspects of sawing operations (sawing, flushing, vacuuming, checking for random cracking, lighting).
- c. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Advanced Concrete Flatwork Finisher.
- d. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

1.3.2 Other Staff

Submit for approval the qualifications and resumes for the following staff:

- a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious materials and tests identified in this specification. Detail the education, training and experience related to the project-specific test methods and deleterious materials in the Petrographer Resume and submit at least 20 days before petrographic and deleterious materials examination is to commence.
- b. Licensed Surveyor: Perform all survey work under the supervision of a Licensed Surveyor.
- c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification.

1.3.3 Preconstruction Testing of Materials

All sampling and testing is required to be performed using an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. Materials are not allowed to be used until notice of acceptance has been given. Additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required is not allowed. Additional tests may be performed by the Government; such Government testing does not relieve any required testing responsibilities.

1.3.3.1 Aggregates

Sample aggregates in the presence of a Government Representative. Obtain samples representative of the materials to be used for the project in accordance with [ASTM D75/D75M](#). Perform all aggregate tests no earlier than 6 months prior to test section construction.

1.3.3.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project. Provide test results less than 5 years old prior to use in the work. Retest chemical admixtures that have been in storage for longer than 6 months or that have been subjected to temperatures outside of manufacturer requirements. Reject if test results do not meet the Level 2 proof of compliance requirements of [ASTM C494/C494M](#).

1.3.3.3 Testing of Cementitious Materials

All materials referenced under paragraph CEMENTITIOUS MATERIALS will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is provided. Provide mill test reports no more than 1 month old, prior to use in the work. Do not use cementitious materials until notice of acceptance has been given. Cementitious materials may be subjected to testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, promptly remove it from the project site. Retest cementitious material that has not been used within 6 months after testing, and reject if test results do not meet manufacturer requirements.

1.3.4 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests to validate the results of the production testing. If the results of the production testing vary by less than 2.0 percent of the Government's test results, the results of the production testing will be used. If the results of the Government and production tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, carefully evaluate each sampling and testing procedure and obtain another series of Government and production tests on duplicate samples of material. If these vary by 4.0 percent or more, use the results of the tests made by the Government and the

Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government does not relieve the specified testing requirements.

1.3.5 Acceptance Requirements

1.3.5.1 Pavement Lots

A lot is that quantity of construction to be evaluated for acceptance with specification requirements. A lot is equal to production paving not to exceed 1000 cubic yards. In order to evaluate thickness, divide each lot into sublots not to exceed 250 cubic yards. Make grade determinations on the lot as a whole. Make surface smoothness determinations on every 0.1 mile segment in each lot. Select sample locations on a random basis in accordance with ASTM D3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot (except for the last lot), and the total number of sublots used and acceptance criteria adjusted accordingly.

1.3.5.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment, including batch tickets with all required acceptance testing. Individuals performing sampling, testing and inspection duties are required to meet the requirements of paragraph: Contractor Quality Control Staff. The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas are in addition to the subplot or lot testing, and the requirements for these areas are the same as those for a subplot or lot. Provide facilities, and where directed personnel, to assist in obtaining samples for any Government testing.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Bulk Cementitious Materials

Provide all cementitious materials in bulk at a temperature, as delivered to storage at the site, not exceeding 150 degrees F. Provide sufficient cementitious materials in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.4.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Store each size of aggregate from each source separately and allow the fine aggregate and the smallest size coarse aggregate to drain. Provide a minimum 24 inch thick sacrificial layer left undisturbed for each aggregate stored on ground or provide a paved or chemically stabilized surface course beneath the stockpiles. Maintain sufficient aggregate at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Do not allow tracked equipment on coarse aggregate stockpiles.

1.4.3 Other Materials

Store reinforcing bars and accessories above the ground on supports.
Store all materials to avoid contamination and deterioration.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, construct each interface to conform to the requirements of both this section and the other section, including tolerances for both.

2.1.1 SURFACE SMOOTHNESS

Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 200 feet, and at the ends of the paving limits for the project. Smoothness requirements do not apply over crowns, drainage structures, or similar penetrations. Maintain detailed notes of the testing results and provide a copy to the Government after each day's testing.

2.1.1.1 Straightedge Testing

Provide the finished surfaces of the pavements with no abrupt change of 1/4 inch or more, and all pavements within the limits specified when checked with an approved 12 foot straightedge. Report measurements to the nearest 1/16 inch. Provide roads, streets, tank hardstands, vehicular parking areas, and open storage areas with a variation from the specified straight edge not greater than 1/4 inch in either the longitudinal or transverse direction.

2.1.1.2 Bumps ("Must Grind" Areas)

Reduce any bumps ("must grind" areas) shown by straightedge measurements which exceed 0.4 inch in height by diamond grinding in accordance with paragraph DIAMOND GRINDING OF PCC SURFACES below until they do not exceed 0.3 inch when retested. Taper such diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding.

2.1.1.3 Testing Method

After the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement, test the entire surface of the pavement in each lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Perform the longitudinal lines at the 1/8th point in from each side of the lane and at the centerline of each paving lane shown on the drawings, regardless of whether multiple lanes are allowed to be paved at the same time. Also test other areas having obvious deviations. Perform longitudinal testing lines continuous across all joints. Perform transverse testing lines for pilot lanes carried to construction joint lines and for fill-in lanes carried 24 inches across construction joints, and the readings in this area applied to the fill-in

lane.

2.1.1.3.1 Straightedge Testing

Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Determine measurements along the entire length of the straight edge.

2.1.2 Edge Slump and Joint Face Deformation

2.1.2.1 Joint Face Deformation

Provide a vertical joint face with a surface within the maximum limits shown in Table 5. Provide the offset measurements from all five Joint Face Deformation Limits from Table 5 at the specified testing frequency. Properly reference all recorded measurements in accordance with paving lane identification and stationing, and submit a report within 10 days after measurement is made. Identify areas requiring replacement within the report.

TABLE 5				
JOINT FACE DEFORMATION LIMITS				
Offset from Straightedge Applied Longitudinally to Pavement Surface (a)	Offset from Straightedge Applied Longitudinally to Vertical Face (b)	Offset from Straightedge Applied Top to Bottom Against the Joint Face (c)	Abrupt Offset in Any Direction (d)	Offset of Joint Face from True Vertical (e)
Non-Airfield Pavement				
1/4 inch	1/4 inch	3/8 inch	1/4 inch	1 inch per 12 inches
(a) Measurement is taken by placing the straightedge longitudinally on the pavement surface 1 inch from the free edge. Record the longitudinal joint face deformation of the joint on a continuous line 1 inch back from the joint line using the 12 foot straightedge advanced one-half its length for each reading.				
(b) Measurement is taken by applying the straightedge longitudinally along the center of the vertical joint face. Record the longitudinal joint face deformation using the 12 foot straightedge advanced one-half its length for each reading.				
(c) Measurement places a 3/8 inch spacer attached to a straightedge and spaced approximately equal to the thickness of the concrete being measured. The offset from straightedge with spacers is measured by placing the spacers against the top and bottom of the vertical concrete face. Record measurements at 5 foot spacings.				

TABLE 5				
JOINT FACE DEFORMATION LIMITS				
Offset from Straightedge Applied Longitudinally to Pavement Surface (a)	Offset from Straightedge Applied Longitudinally to Vertical Face (b)	Offset from Straightedge Applied Top to Bottom Against the Joint Face (c)	Abrupt Offset in Any Direction (d)	Offset of Joint Face from True Vertical (e)
(d) Check for abrupt offsets at any location that an abrupt change in the joint face plane appears to be present through use of a 12 foot straightedge.				
(e) Measurement of the offset from the joint face to a level in the true vertical position against the joint face. Record measurements at 5 foot spacings.				

2.1.2.2 Edge Slump Determination

Test the pavement surface to determine edge slump immediately after the concrete has hardened sufficiently to permit walking thereon. Perform testing with a minimum 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified above. Place the straightedge transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Record measurements at 5 to 10 foot spacings, as directed, commencing at the header where paving was started. Initially record measurements at 5 foot intervals in each lane. When no deficiencies are present after 5 measurements, the interval may be increased. The maximum interval is 10 feet. When any deficiencies exist, return the interval to 5 feet. Perform other tests of the exposed joint face to produce a uniform, true vertical joint face. Properly reference all recorded measurements in accordance with paving lane identification and stationing, and submit a report within 10 days after measurement is made. Identify areas requiring replacement within the report.

2.1.2.3 Excessive Edge Slump or Joint Face Deformation

When edge slump or joint face deformation exceeding the limits specified above is encountered on either side of the paving lane, record additional straightedge measurements to define the linear limits of the excessive slump or joint face deformation. Remove and replace concrete slabs having excessive edge slump or joint deformation to the next transverse joint in conformance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Discontinue use of slip-form paving equipment and procedures that fail to consistently provide edges within the specified tolerances on edge slump and joint face deformation and construct by means of standard paving procedures using fixed forms.

2.1.3 Plan Grade

Within 5 days after paving of each lot, test the finished surface of the pavement area by running lines of levels at intervals corresponding with

every longitudinal and transverse joint to determine the elevation at each joint intersection. Record the results of this survey and provide a copy signed by a registered professional land surveyor to the Government at the completion of the survey of each lot. Provide surfaces of heavy-duty pavements other than airfield pavements that vary less than $\frac{3}{4}$ inch. The above deviations from the approved grade line and elevation are not permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. Provide finished surfaces of new abutting pavements that coincide at their juncture.

2.1.4 Flexural Strength

Each lot of pavement will be evaluated for acceptance for flexural strength in accordance with paragraph Sampling and Testing and paragraph Computations.

2.1.4.1 Sampling and Testing

For acceptance, obtain one composite sample of concrete from each subplot in accordance with **ASTM C172/C172M** from one batch or truckload.

2.1.4.2 Computations

Average the eight 14-day strength tests for the lot. Use the average strength in accordance with paragraph Concrete Strength For Final Acceptance.

2.1.5 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Drill two cores, between **4 and 6 inches** in diameter, from the pavement, per subplot (8 per lot). Drill the cores within 3 days after lot placement, fill the core holes with an approved **concrete patching mixture**, and respray the cored areas with curing compound. Prevent the core hole from drying or damage until backfilled. Complete backfilling of core hole during the subsequent production placement or within 5 calendar days, whichever occurs first. Record eight measurements of thickness around the circumference of each core and one in the center, in accordance with **ASTM C174/C174M**. Provide the results with the thickness measurement data. Average the pavement thickness from the 8 cores for the lot and evaluate as described in paragraph Payment Adjustment For Thickness above.

2.1.6 Evaluation of Cores

Record and submit testing, inspection, and evaluation of each core for mortar-rich surface, uniformity of aggregate distribution, segregation, voids, cracks, and depth of reinforcement or dowels (if present). Moisten the core with water to visibly expose the aggregate and take a minimum of three photographs of the sides of the core's entire length, rotating the core approximately 120 degrees between photographs. Provide photographs with the clarity and quality to identify the defects identified above. Each core is to be identified on the top with the core number referenced to paving lot plan view. Photograph the core against a contrasting background, in profile, and with an extended tape measure parallel and to the right of the core with incremental measurements clearly visible. Provide plan view of location for each core. Store the cores and make available to the Government when requested, until otherwise directed.

2.1.7 Diamond Grinding of PCC Surfaces

In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth and surface area is limited below. Reduce high areas by diamond grinding the hardened concrete with approved equipment after the concrete is at a minimum age of 14 days. Perform diamond grinding by sawing with an industrial diamond abrasive which is impregnated in the saw blades. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the concrete pavement or joint faces. Utilize diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 55 to 60 blades per 12 inches of cutting head width, and cut a path with a minimum width of 3 ft. Diamond grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints is not permitted. The maximum area corrected by diamond grinding the surface of the hardened concrete is 10 percent of the total area of any subplot. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above in conformance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Repair aggregate popouts using the core and patch method of paragraph REPAIRING SPALLS ALONG JOINTS. All areas in which diamond grinding has been performed are subject to the thickness tolerances specified in paragraph Thickness, above.

Prior to production diamond grinding operations, perform a test section at the approved location. Perform a test section that consists of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish, transition between adjacent passes, and the results of crossing a transverse joint. Production diamond grinding operations are not to be performed prior to approval.

2.2 CEMENTITIOUS MATERIALS

Provide cementitious materials consisting of portland cement, blended cement or portland cement in combination with supplementary cementitious materials (SCM), that conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.2.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type I or II , .

2.2.2 Blended Cements

Provide blended cement conforming to ASTM C595/C595M, Type IP, IS, or IL. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include a written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. Provide limestone added to the Type IL blend that is interground with the cement clinker.

Include a written statement from the manufacturer that the amount of limestone in the finished cement does not vary more than plus or minus 2.5 mass percent of the finished cement from lot to lot or within a lot. Limit the percent of slag, pozzolan, or limestone to a maximum of IS(50), IP(35) or IL(15). The percentage and type of mineral admixture used in the blend is not allowed to change from that submitted for the aggregate evaluation and mixture proportioning.

2.2.3 Pozzolan

2.2.3.1 Fly Ash

Provide fly ash that conforms to [ASTM C618](#), Class F, including the optional requirement for uniformity with a loss on ignition not exceeding 3 percent. Provide Class F fly ash for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 4 percent.

2.2.3.2 Raw or Calcined Natural Pozzolan

Provide natural pozzolan that is raw or calcined and conforms to [ASTM C618](#), Class N, including the optional requirement for uniformity with a loss on ignition not exceeding 3 percent. Provide Class N pozzolan for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 4 percent.

2.2.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Provide Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) that conforms to [ASTM C618](#), Class F or N, and the following additional requirements:

- a. The strength activity index at 28 days of age of at least 95 percent of the control specimens.
- b. The average particle size is a maximum of 6 microns.

2.2.4 Slag Cement

Provide slag cement (ground-granulated blast-furnace slag) that conforms to [ASTM C989/C989M](#), Grade 100 or Grade 120.

2.2.5 Supplementary Cementitious Materials (SCM) Content

Use of one of the SCMs listed below is optional, unless the SCM is required to mitigate ASR. The use of SCMs is encouraged in accordance with Section [01 33 29](#) SUSTAINABILITY REQUIREMENTS AND REPORTING.

TABLE 6		
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT		
Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ > 70 percent	25	35

TABLE 6		
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT		
Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ > 80 percent	20	35
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ > 90 percent	15	35
UFFA and UFP	7	16
Slag Cement	40	50

2.3 AGGREGATES

Provide aggregates meeting the requirements of this specification. If aggregate sources in the project area do not meet the requirements of this specification, provide aggregates from sources outside the project area.

2.3.1 Aggregate Sources

2.3.1.1 Durability of Coarse Aggregate

Provide aggregate with a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. Include a condition survey of the existing concrete and a review of the concrete-making materials, including coarse aggregates, cement, and mineral admixtures in the service record. Consider the previous aggregate source and test results, cement mill certificate data, mineral admixture chemical and physical composition, and the mix design (cement factor and water-cementitious material ratio) in the review. Provide service record performed by an independent third party professional engineer, petrographer, or concrete materials engineer along with their resume. Include photographs and a written report addressing D-cracks and popouts in accordance with [ACI 201.1R](#) in the service record. Provide coarse aggregate with a durability factor of 80 or more when subjected to freezing and thawing of specimens prepared in accordance with [ASTM C1646/C1646M](#) and tested in accordance with [ASTM C666/C666M](#), Procedure A, when a coarse aggregate size group or source proposed for use does not have a satisfactory demonstrable service record. Test all coarse aggregate size groups and sources proposed for use individually.

2.3.1.2 Alkali-Silica Reactivity

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity. Test all size groups and sources proposed for use individually.

- a. Evaluate the aggregate size groups and sources separately using [ASTM C1260](#). Reject individual aggregates with test results that indicate an expansion of greater than 0.08 percent after 28 days of immersion in 1N NaOH solution, or perform additional testing as follows: utilize the proposed portland cement, blended cement, and SCM, or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, test in accordance with

ASTM C1567. If Lithium Nitrate is being evaluated, with or without SCMs, test in accordance with **COE CRD-C 662**. Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity.

- b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for evaluation and acceptance.

2.3.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, provide the combined aggregate grading meeting the following requirements:

- a. Provide materials selected and the proportions used such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point and its associated production tolerance thus determined falls within the parallelogram described therein. Refer to **TSPWG M 3-250-04.97-05** for combined aggregate plot locations for the intended placement technique(s).
- b. Determine the Coarseness Factor (CF) from the following equation:
$$CF = \frac{(\text{cumulative percent retained on the } 3/8 \text{ inch sieve})(100)}{(\text{cumulative percent retained on the No. 8 sieve})}$$
- c. The Workability Factor (WF) is defined as the percent passing the No. 8 sieve based on the combined aggregate gradation. Adjust the WF, prorated upwards only, by 2.5 percentage points for each 94 pounds per cubic yard of cementitious material greater than 564 pounds per cubic yard.
- d. Plot a diagram using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram, plot a parallelogram with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, revise the grading of each size of aggregate used and the proportions selected as necessary.
- e. Plot the associated production tolerance limits, identified in Table 17, around the CF and adjusted WF point.

2.3.2 Coarse Aggregate

2.3.2.1 Coarse Aggregate Composition

Provide coarse aggregate consisting of crushed or uncrushed gravel, crushed stone, or a combination thereof. Provide aggregates, as delivered to the mixers, consisting of clean, hard, uncoated particles meeting the requirements of **ASTM C33/C33M** except as specified herein. . Provide coarse aggregate with no more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with **ASTM C131/C131M**. Provide coarse aggregates with a maximum sodium sulfate soundness loss of 12

percent, or with a magnesium sulfate soundness loss of 18 percent after five cycles when tested in accordance with [ASTM C88](#).

2.3.2.2 Particle Shape Characteristics

Provide particles of the coarse aggregate that are generally spherical or cubical in shape. The quantity of flat particles and elongated particles in any size group coarser than the [3/8 inch](#) sieve are not allowed to exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of [ASTM D4791](#), Method A. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.3.2.3 Size and Grading

Provide coarse aggregate with a nominal maximum size (as defined in [ASTM C125](#)) of [1.5 inches](#) with a minimum of 10 percent retained on the 1.0 inch sieve of the proposed combined aggregate gradation that meets the criteria of paragraph COMBINED AGGREGATE GRADATION. Grade and provide the coarse aggregates in a minimum of two size groups meeting the individual grading requirements of [ASTM C33/C33M](#), Size No. 4 ([1.5 inches to 0.75 inch](#)), Size No. 67 ([0.75 inch to No. 4](#)), or Size No. 57 ([1.0 ins. to No. 4](#)).

A third coarse aggregate size group may be required to meet the criteria of paragraph Combined Aggregate Gradation.

Mix designs that include a minimum of three coarse aggregate size groups can use grading limits not defined by [ASTM C33/C33M](#) provided all other requirements are met. Provide upper and lower grading limits of historic gradations and for all proposed coarse aggregates not defined by [ASTM C33/C33M](#) but intended for use in the mix design.

2.3.2.4 Deleterious Material - Heavy Duty Pavements

The amount of deleterious material in each size group of coarse aggregate is not to exceed the limits in Table 7B when tested as indicated.

TABLE 7B	
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR HEAVY DUTY PAVEMENTS	
Percentage by Mass	
Clay lumps and friable particles (ASTM C142/C142M)	2.0
Material finer than No. 200 sieve (ASTM C117)	1.0
Lightweight particles (ASTM C123/C123M)	1.0
Other soft particles (COE CRD-C 130)	2.0
Total of all deleterious substances, exclusive of material finer than No. 200 sieve	5.0

The limit for material finer than the [No. 200 sieve](#) is allowed to be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. Use a separation medium for lightweight particles with a density of 2.0 specific gravity. This limit

does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.3.3 Fine Aggregate

2.3.3.1 Fine Aggregate Composition

Provide fine aggregate consisting of natural sand, manufactured sand, or a combination of the two, each composed of clean, hard, durable particles meeting the requirements of [ASTM C33/C33M](#). Stockpile and batch each type of fine aggregate separately. Provide fine aggregate with particles that are generally spherical or cubical in shape. For fine aggregate provided as a combination of sources, test each source individually.

2.3.3.2 Grading

Provide fine aggregate, as delivered to the mixer, with a grading that conforms to the requirements of [ASTM C33/C33M](#) and having a fineness modulus of not less than 2.50 nor more than 3.40. For fine aggregate supplied as a combination of sources, determine the fineness modulus on a composite sample.

2.3.3.3 Deleterious Material

The amount of deleterious material in the fine aggregate is not to exceed the limits listed in Table 8 when performed on the full sample:

TABLE 8	
LIMITS OF DELETERIOUS MATERIALS IN FINE AGGREGATE	
Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than No. 200 sieve ASTM C117	3.0
Lightweight particles ASTM C123/C123M using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all above	3.0

2.4 CHEMICAL ADMIXTURES

2.4.1 General Requirements

Only use chemical admixtures when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. Provide all chemical admixtures from the same manufacturer. Provide air-entraining admixture conforming to [ASTM C260/C260M](#). Use an accelerating admixture conforming to [ASTM C494/C494M](#), Type C or Type E, when specified in paragraph MIXTURE PROPORTIONS below provided it is not used to reduce the amount of cementitious material. Calcium chloride and admixtures containing calcium chloride are not allowed. Provide retarding or water-reducing admixture that meet the requirements of [ASTM C494/C494M](#),

Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. [ASTM C494/C494M](#), Type F and G high range water reducing admixtures and Type S specific performance admixtures are not allowed. [ASTM C1017/C1017M](#) flowable admixtures are not allowed.

2.5 MEMBRANE FORMING CURING COMPOUND

Provide membrane forming curing compound that conforms to [ASTM C309](#), white-pigmented Type 2, Class B.

2.6 WATER

Provide water for mixing and curing that is fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, can be used if it meets the requirements of [ASTM C1602/C1602M](#).

2.7 JOINT MATERIALS

2.7.1 Expansion Joint Material

Provide preformed expansion joint filler material conforming to [ASTM D1752](#) Type II . Provide expansion joint filler that is [3/4 inch](#) thick, unless otherwise indicated, and provided in a single full depth piece.

2.7.2 Slip Joint Material

Provide slip joint material that is [1/4 inch](#) thick expansion joint filler, unless otherwise indicated, conforming to paragraph EXPANSION JOINT MATERIAL.

2.8 REINFORCING

Provide reinforcement that is free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties is not allowed to be used.

2.8.1 Reinforcing Bars and Bar Mats

Provide reinforcing bars conforming to [ASTM A615/A615M](#), billet-steel, Grade 60 . Provide bar mats conforming to [ASTM A184/A184M](#). The bar members may be billet rail or axle steel.

2.8.2 Welded Wire Reinforcement

Provide welded wire reinforcement that is deformed or smooth, conforming to [ASTM A1064/A1064M](#), and provided in flat sheets.

2.9 DOWELS AND TIE BARS

2.9.1 [Dowels](#)

Provide dowels in single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels are to be free of loose, flaky rust and loose scale and be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by

shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels are required to be smooth steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Epoxy coat dowels in conformance with Type 1 coating requirements of ASTM A1078/A1078M, to include the ends. Provide grout retention rings that are fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.9.2 Dowel Bar Assemblies

Provide dowel bar assemblies that consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. Provide dowels that are welded to the assembly or held firmly by mechanical locking arrangements that prevent them from rising, sliding out, or becoming distorted during paving operations.

2.9.3 Tie Bars

Provide tie bars that are deformed steel bars conforming to ASTM A615/A615M, or ASTM A996/A996M, Grade 60 , and of the sizes and dimensions indicated.

2.10 EPOXY RESIN

Provide epoxy-resin materials that consist of two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials meet the following requirements:

- a. Type IV, Grade 3 for use for embedding dowels and anchor bolts.
- b. Type III, Grade as required for use as patching materials for complete filling of spalls, saw-cut runouts, and other voids and for use in preparing epoxy resin mortar.
- c. Type IV, Grade 1 for use for injecting cracks.
- d. Type V, Grade as required for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete.

2.11 EQUIPMENT

Maintain all plant, equipment, tools, and machines used in the work in satisfactory working conditions at all times. Submit the following:

- a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.
- b. Obtain National Ready Mixed Concrete Association (NRMCA) certification of the concrete plant, at no expense to the Government. Provide inspection report of the concrete plant by an engineer approved by the NRMCA. The NRMCA certified engineer cannot be employed by the primary contractor or a subcontractor. A list of NRMCA approved engineers is available on the NRMCA website at <http://www.nrmca.org>. Submit a copy of the NRMCA QC Manual Section 3 Concrete Plant Certification

Checklist, [NRMCA Certificate of Conformance](#), and Calibration documentation on all measuring and weighing devices prior to uniformity testing.

- c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.
- d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature is required to show that the equipment meets all details of these specifications.

2.11.1 Batching and Mixing Plant

2.11.1.1 Location

[Utilize a batching and mixing plant](#) off Government premises no more than 45 minutes haul and gate security check time from the placing site. Provide operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

2.11.1.2 Type and Capacity

[Utilize](#) a batching and mixing plant consisting of a stationary-type central mix plant, including permanent installations and portable or relocatable plants installed on stable foundations. Provide a plant designed and operated to produce concrete within the specified tolerances, with a minimum capacity of [250 cubic yards](#) per hour, that conforms to the requirements of [NRMCA QC 3](#) including provisions addressing:

- 1. Material Storage and Handling
- 2. Batching Equipment
- 3. Central Mixer
- 4. Ticketing System
- 5. Delivery System

2.11.1.3 Ready-Mixed Concrete

[Provide ready-mixed concrete in accordance with ASTM C94/C94M.](#)

2.11.1.4 Concrete Made by Volumetric Batching and Continuous Mixing

[Provide concrete made by volumetric batching and continuous mixing in accordance with ASTM C685/C685M.](#)

2.11.1.5 Concrete Uniformity Requirements

[Provide concrete meeting the uniformity requirements of ASTM C94/C94M. Perform uniformity testing no earlier than 6 months before placement using the approved mixture proportions for the project. Submit mixer performance \(uniformity\) testing showing concrete is within the limits of ASTM C94/C94M.](#)

2.11.2 Concrete Mixers

[Provide truck mixers that are capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. Do](#)

not charge the mixers in excess of the capacity recommended by the manufacturer. Operate the mixers at the drum or mixing blade speed designated by the manufacturer. Maintain the mixers in satisfactory operating condition, with the mixer drums kept free of hardened concrete. Replace mixer blades or paddles when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

2.11.2.1 Truck

Provide only truck mixers designed for mixing or transporting paving concrete with extra large blading and rear opening specifically for low-slump paving concrete. Provide truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof that conform to the requirements of [ASTM C94/C94M](#). Any changes to the mix constituents or sequence of charging the truck mixer requires an additional three consecutive passing batches. Determine the number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete by uniformity tests as specified in [ASTM C94/C94M](#) and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, discontinue use of the mixer until the condition is corrected. Water is not allowed to be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Inject water into the head of the mixer (end opposite the discharge opening) drum under pressure, and turn the drum or blades a minimum of 30 additional revolutions at mixing speed. The addition of water to the batch at any later time is not allowed.

2.11.3 Transporting Equipment

Transport fixed form concrete in non-agitating equipment or approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. Provide transporting equipment designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.11.4 Transfer and Spreading Equipment

Provide a Material Transfer Vehicle (MTV) capable of moving between the hauling equipment and the paver and equipped with a swing conveyor that delivers material to the paver from outside the paving lane without making contact with the paver while allowing the paver to operate at a constant speed.

2.11.5 Paver-Finisher

Provide paver-finisher consisting of a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement, with a minimum weight of [2200 pounds per foot](#) of lane width, and powered by an engine having a minimum [6.0 horsepower per foot](#) of lane width. The paver-finisher is required to spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for

forming the pavement are required to be easily adjustable in width and thickness. In addition to other spreaders required by paragraph above, equip the paver-finisher with a full width knock-down auger or plow mechanism, capable of operating in both directions, which evenly spreads the fresh concrete in front of the screed or extrusion plate.

2.11.5.1 Vibrators

Provide gang mounted immersion vibrators at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. Provide vibrators that are automatically controlled to immediately stop as forward motion of the paver ceases. Provide the spacing of the immersion vibrators across the paving lane as necessary to properly consolidate the concrete, with a maximum clear distance between vibrators of 30 inches and outside vibrators a maximum of 12 inches from the lane edge. Determine vibrator frequency and amplitude per COE CRD-C 521.

2.11.5.2 Screed or Extrusion Plate

Equip the paver-finisher with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface and finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. Provide adjustment for variation in lane width or thickness and to prevent more than 8 inches of the screed or extrusion plate extending over previously placed concrete on either side when paving fill-in lanes. Repair or replace machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures.

2.11.5.3 Other Types of Finishing Equipment

Clary screeds (triple drum roller screeds), other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to approval. Only use vibrating screeds or pans for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

2.11.5.4 Fixed Forms

Provide paver-finisher equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. When traveling on new or existing concrete to remain, provide paver-finishers traveling on guide rails located outside of the paving lane that are equipped with wheels that will not cause damage or spalling to concrete joint edges to remain.

2.11.6 Curing Equipment

Provide equipment for applying membrane-forming curing compound mounted on a self-propelled frame that spans the paving lane. Constantly agitate the curing compound reservoir mechanically (not air) during operation and provide a means for completely draining the reservoir. Provide a spraying system that consists of a mechanically powered pump which maintains constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to provide

uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. Protect all spray nozzles with wind screens. Calibrate the spraying system in accordance with [ASTM D2995](#), Method A, for the rate of application required in paragraph MEMBRANE CURING. Provide hand-operated sprayers allowed by that paragraph with compressed air supplied by a mechanical air compressor. Immediately replace curing equipment if it fails to apply an even coating of compound at the specified rate.

2.11.7 Texturing Equipment

Provide texturing equipment as specified below. Before use, demonstrate the texturing equipment on the test section, and modify the equipment as necessary to produce the texture directed.

2.11.7.1 Burlap Drag

Securely attach a burlap drag to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Provide length of the material between [24 to 36 inches](#) dragging flat on the pavement surface and with a width at least equal to the width of the slab. Provide clean, reasonably new burlap material, completely saturated with water before attachment to the frame, moistened before start of use, and kept clean and maintained moist during use. Provide burlap conforming to [AASHTO M 182](#), Class 3 or 4.

2.11.7.2 Broom

Apply surface texture using an approved mechanical stiff bristle broom drag of a type that provides a uniformly scored surface transverse to the pavement center line. Provide broom capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure that results in scores uniform in appearance and approximately [1/16 inch](#) in depth but not more than [1/8 inch](#) in depth.

2.11.8 Sawing Equipment

Provide equipment for sawing joints and for other similar sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. Provide saws capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval. No change to the initial sawcut depth is permitted.

2.11.9 Straightedge

Provide and maintain at the job site, in good condition, a minimum [12 foot](#) straightedge for each paving train for testing the hardened portland cement concrete surfaces. Provide straightedges constructed of aluminum or magnesium alloy and blades of box or box-girder cross section with flat bottom, adequately reinforced to maintain rigidity and accuracy. Provide straightedges with handles for operation on the pavement.

2.11.10 Work Bridge

Provide a self-propelled work bridge capable of spanning the required paving lane width where workmen can efficiently and adequately reach the pavement surface.

2.11.11 Hand Finishing Tools

Provide hand finishing equipment in accordance with the provisions of this specification. Use the hand method only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Keep supplemental hand finishing for machine finished pavement to an absolute minimum. Do not seal the paving surface with steel trowels.

2.12 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.12.1 Specified Flexural Strength

Specified flexural strength, R , for concrete is 650 psi at 90 days, as determined by equivalent flexural strength, as specified in paragraph Mixture Proportioning For Flexural Strength below.

2.12.2 Allowable Water-Cementitious Materials Ratio

The allowable water-cementitious material ratio is 0.38 to 0.45. The water-cementitious material ratio is the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1.

2.12.3 Air Content

Provide concrete that is air-entrained with a total air content of 6.0 plus or minus 1.5 percentage points, at the point of placement. Determine air content in accordance with ASTM C231/C231M.

2.12.4 Slump

The maximum allowable slump of the concrete at the point of placement is 3 inches for pavement constructed with fixed forms.

2.12.5 Concrete Temperature

The temperature of the concrete as delivered is required to conform to the requirements of paragraphs Paving In Hot Weather and Paving In Cold Weather. Determine the temperature of concrete in accordance with ASTM C1064/C1064M.

2.12.6 Concrete Strength for Final Acceptance

The strength of the concrete will be considered acceptable when the average equivalent 90-day flexural strengths for each lot are above the 'Specified Flexural Strength' as determined by correlation with 14-day compressive strength tests specified in paragraph Mixture Proportioning For Flexural Strength below, and no individual set (2 specimens per subplot) in the lot are 25 psi or more below the equivalent 'Specified Flexural Strength'. If any lot or subplot, respectively, fails to meet the above criteria, remove and replace the lot or subplot at no additional cost to the Government. This is in addition to and does not replace the

average strength required for day-to-day CQC operations as specified in paragraph Average Cqc Flexural Strength Required For Mixtures, below.

2.13 MIXTURE PROPORTIONS

2.13.1 Mixture Proportions Composition

Provide concrete composed of cementitious material, water, fine and coarse aggregates, and admixtures. Include supplementary Cementitious Materials (SCM) choice and usage in accordance with paragraph Supplementary Cementitious Materials (SCM) Content. Provide a minimum total cementitious materials content of **517 pounds per cubic yard**. Acceptable admixtures consist of air entraining admixture and may also include, as approved, water-reducing admixture, retarding admixture, water-reducing and retarding admixtures, .

2.13.2 Proportioning Studies

Perform trial design batches, mixture proportioning studies, and testing, at no expense to the Government. Submit for approval the **Preliminary Proposed Proportioning** to include items a., b., and i. below a minimum of 21 days prior to beginning a mixture proportioning study. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. Include a statement summarizing the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic **yard** basis. Base aggregate quantities on the mass in a saturated surface dry condition. Provide test results demonstrating that the proposed mixture proportions produce concrete of the qualities indicated. Base methodology for trial mixtures having proportions, slumps, and air content suitable for the work as described in **ACI 211.1**, modified as necessary to accommodate flexural strength. **ACI 211.1** can be supplemented with **ACI 325.14R**. Submit test results including:

- a. Individual coarse and fine aggregate gradations and plots. Include historic gradation averages and standard deviations on individual sieves for each aggregate size group.
- b. Combined aggregate gradation and coarseness vs. workability plots.
- c. Coarse aggregate quality test results.
- d. Fine aggregate quality test results.
- e. Mill certificates for cement and supplementary cementitious materials.
- f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating admixtures.
- g. Specified flexural strength, slump, and air content.
- h. Documentation of required average CQC flexural strength, R_a .
- i. Recommended proportions and volumes for proposed mixture and each of three trial water-cementitious materials ratios for each proposed placement method.
- j. Individual beam and cylinder breaks.
- k. Flexural and compressive strength summaries and plots.
- l. Correlation ratios for acceptance testing and CQC testing.m. Historical record of **ACI 214R** strength test results, documenting production standard deviation (if available).
- n. Narrative discussing methodology on how the mix design was developed in accordance with **ACI 211.1** and **ACI 325.14R**.
- o. Alternative aggregate blending to be used during the test section if necessary to meet the required surface and consolidation requirements.

2.13.2.1 Water-Cementitious Materials Ratio

Perform at least three different water-cementitious materials ratios, within the limits specified in paragraph Allowable Water-Cementitious Materials Ratio, which produce a range of strength encompassing that required on the project. The minimum and maximum water-cementitious materials ratios of the approved mix design become the minimum and maximum water-cementitious materials ratio for the project during production.

2.13.2.2 Trial Mixture Studies

Perform separate sets of trial mixture studies made for each combination of cementitious materials and each combination of admixtures proposed for use. No combinations are to be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerating or retarding admixture can be used without separate trial mixture study. Perform separate trial mixture studies for each placing method (fixed form or hand placement) proposed. Report the temperature of concrete in each trial batch. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding. Proportion laboratory trial mixtures for maximum slump and air content, as permitted by the placement method being utilized.

2.13.2.3 Mixture Proportioning for Flexural Strength

Follow the step by step procedure below:

- a. Fabricate all beams and cylinders for each mixture from the same batch or blend of batches. Fabricate and cure all beams and cylinders in accordance with ASTM C192/C192M, using 6 x 6 inches steel beam molds and 6 x 12 inches single-use cylinder molds.
- b. Cure test beams from each mixture for 3, 7, 14, 28 and 90-day flexural tests; 6 beams to be tested per age.
- c. Cure test cylinders from each mixture for 3, 7, 14, 28 and 90-day compressive strength tests; 6 cylinders to be tested per age.
- d. Test beams in accordance with ASTM C78/C78M, cylinders in accordance with ASTM C39/C39M.
- e. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:
 - 3-day flexural strength
 - 7-day flexural strength
 - 14-day flexural strength
 - 28-day flexural strength
 - 90-day flexural strength
 - 3-day compressive strength
 - 7-day compressive strength
 - 14-day compressive strength
 - 28-day compressive strength
 - 90-day compressive strength
- f. From these graphs select a w/c that produces a mixture giving a 90-day flexural strength equal to the required strength determined in

accordance with paragraph Average CQC Flexural Strength Required for Mixtures.

- g. Using the above selected w/c, select from the graphs the expected 3, 7, 14, 28 90-day flexural strengths and the expected 3, 7, 14, 28 90-day compressive strengths for the mixture.
- h. From the above expected strengths for the selected mixture determine the following Correlation Ratios:
 - (1) Ratio of the 14-day compressive strength of the selected mixture to the 90-day flexural strength of the mixture (for acceptance).
 - (2) Ratio of the 7-day compressive strength of the selected mixture to the 90-day flexural strength of the mixture (for CQC control).
- i. If there is a change in materials, perform additional mixture design studies using the new materials and new Correlation Ratios determined.
- j. No concrete pavement placement is allowed until the mixture proportions are approved. The approved water-cementitious materials ratio is restricted to the minimum and maximum values specified in paragraph Water-Cementitious Materials Ratio and is not to be increased without written approval.

2.13.3 Average CQC Flexural Strength Required for Mixtures

- a. In order to meet the strength requirements specified in paragraph SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES during production, the mixture proportions selected during mixture proportioning studies and used during construction require an average CQC flexural strength, R_a , exceeding the specified flexural strength, R , by the amount indicated below.
- b. The required average CQC flexural strength, R_a , is used only for proportioning studies and CQC operations as specified in paragraph Concrete Strength Testing for CQC.
- c. Acceptance of production flexural strength results is based on the specified flexural strength R specified in paragraph: Specified Flexural Strength.

2.13.3.1 From Previous Test Records

Where a concrete production facility has previous test records current to within 18 months, establish a standard deviation in accordance with the applicable provisions of ACI 214R. Include test records from which a standard deviation is calculated that represent materials, quality control procedures, and conditions similar to those expected, that represent concrete produced to meet a specified flexural strength or strengths within 150 psi of the 90-day flexural strength specified for the proposed work, and that consist of at least 30 consecutive tests. Perform verification testing to document the current strength. A strength test is the average of the strengths of two specimens made from the same sample of concrete and tested at 90 days. Required average CQC flexural strength, R_a , used as the basis for selection of concrete proportions is the value from the equation that follows, using the standard deviation as determined above:

$$R_a = R + 1.34S$$

Where: S = standard deviation
R = specified flexural strength
Ra = required average CQC flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, establish a standard deviation as the product of the calculated standard deviation and a modification factor from Table 13:

TABLE 13	
MODIFICATION FACTOR FOR STANDARD DEVIATION	
NUMBER OF TESTS	MODIFICATION FACTOR
20	1.08
25	1.03
30 or more	1.00

2.13.3.2 Without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, determine the required average CQC flexural strength, Ra, by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following actions to prepare for paving operations. If used, place cleaned, coated, and adequately supported forms. Have any reinforcing steel needed at the paving site; all transporting and transfer equipment ready for use, clean, and free of hardened concrete and foreign material; equipment for spreading, consolidating, screeding, finishing, and texturing concrete at the paving site, clean and in proper working order; and all equipment and material for curing and for protecting concrete from weather or mechanical damage at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Precaution

When windy conditions during paving appear probable, have equipment and material at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete. During these conditions, record and report the evaporation rate hourly.

3.1.2 Proposed Techniques

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment and profilographs; repair in accordance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS, demolition of existing pavements, as specified; pavement diamond grinding

equipment and procedures. Submit for approval the following items:

- a. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.
- b. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or inclement weather conditions
- c. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes, fill-in lanes, and hand placement areas. Include stationing for reference to all sampling and testing performed. Deviations from the jointing pattern shown on the drawings are not allowed without written approval of the design engineer.
- d. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.
- e. Data on the curing equipment, media and methods to be used.
- f. Methods to measure pavement smoothness.
- g. A description of the equipment and methods to be used for grinding and repairs.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Confirm the underlying material upon which concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, confirm the underlying material is well drained and has been satisfactorily graded and uniformly compacted in accordance with the applicable contract documents. Trim high areas to proper elevation. Fill and compact low areas to a condition similar to that of surrounding grade, or fill with concrete monolithically with the pavement. Low areas filled with concrete are not to be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the paver.

3.2.2 Traffic on Underlying Material

After the underlying material has been prepared for concrete placement, equipment is not permitted thereon with exception of the paver. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. Rework and repair the surface before concrete is placed. Transporting equipment is not to be allowed to operate on the prepared and compacted underlying material in front of the paver-finisher.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Immediately cover and protect all unhardened concrete from rain or other damaging weather. Suspend placement of concrete whenever rain, high winds, or other weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete.

Remove and replace any slab damaged by rain or other weather, as defined in paragraph Weak Surfaces, full depth, by full slab width, to the nearest original joint as specified in paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS, at no expense to the Government.

3.3.2 Paving in Hot Weather

Prepare for hot weather paving in accordance with [ACI 305R](#). When the ambient temperature during paving is expected to exceed [90 degrees F](#), properly place and finish the concrete in accordance with procedures previously submitted, approved, and as specified herein. Provide concrete that does not exceed the temperature shown in Table 14 below when measured in accordance with [ASTM C1064/C1064M](#) at the time of delivery. Cool the mixing water or aggregates or place in the cooler part of the day to obtain an adequate placing temperature. Cool steel forms and reinforcing as needed to maintain steel temperatures below [120 degrees F](#). Cool or protect transporting and placing equipment if necessary to maintain proper concrete placing temperature. Keep the finished surfaces of the newly laid pavement damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

TABLE 14	
Maximum Allowable Concrete Placing Temperature	
Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees F
Greater than 60	90
55-60	85
Less than 55	75

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of [ACI 305R](#). In addition to the protective measures specified in the previous paragraph, further

protect the concrete placement by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. If monomolecular films are used, apply only after finishing is complete, do not use in the finishing process, and follow manufacturer recommendations. Immediately commence curing procedures when such water treatment is stopped. Repair plastic shrinkage cracks in accordance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Never trowel over or fill plastic shrinkage cracks with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving is required to conform to **ACI 306R**. Use special protection measures, as specified herein, if freezing temperatures are anticipated or occur before the expiration of the specified curing period. Do not begin placement of concrete unless the ambient temperature is at least **35 degrees F** and rising. Thereafter, halt placement of concrete whenever the ambient temperature drops below **40 degrees F**. When the ambient temperature is less than **50 degrees F**, the temperature of the concrete when placed is required to be not less than **50 degrees F** nor more than **75 degrees F**. Provide heating of the mixing water or aggregates as required to regulate the plastic concrete temperature. Provide materials entering the mixer that are free from ice, snow, or frozen lumps. Do not incorporate salt, chemicals or other materials in the concrete to prevent freezing. Provide covering and other means for maintaining the concrete at a temperature of at least 10 degrees C 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period as defined in paragraph Protection of Concrete. Remove pavement slabs, full depth by full width, damaged by freezing or falling below freezing temperature to the nearest planned joint, and replace as specified in paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS, at no expense to the Government.

3.4 CONCRETE PRODUCTION

Provide batching, mixing, and transporting equipment with a capacity sufficient to **maintain a continuous, uniform forward movement of the paving operation**. Deposit concrete transported in truck mixers in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the truck mixer. If the ambient temperature is above **90 degrees F**, the time is reduced to 60 minutes. Accompany every load of concrete delivered to the paving site with a batch ticket from the operator of the batching plant. Provide batch ticket information required by **ASTM C94/C94M** on approved forms. In addition provide design quantities in mass or volume for all materials, batching tolerances of all materials, mixture batching time, and design and actual water cementitious materials ratio on each batch delivered, and the time of day on all batch tickets. Provide batch tickets for each truck delivered as part of the lot acceptance package to the placing foreman to maintain on file and deliver them to the Government weekly.

3.4.1 Batching and Mixing Concrete

Remove any equipment which fails to perform as specified immediately from use until properly repaired and adjusted or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Operate non-agitating equipment only on smooth roads and for haul time less than 30 minutes. Deposit concrete as close as possible to its final

position in the paving lane. Operate all equipment to discharge and transfer concrete without segregation. Dumping of concrete in discrete piles is not permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete is permitted. No equipment is permitted to operate on the grade in front of the paver.

3.5 PAVING

3.5.1 General Requirements

Construct pavement with paving and finishing equipment utilizing rigid fixed forms. Provide paving and finishing equipment and procedures resulting in paving lanes of the required width at a rate of at least 2.5 feet of paving lane per minute on a routine basis. Control paving equipment and its operation, and coordinate with all other operations, such that the paver-finisher has a continuous forward movement at a reasonably uniform speed from beginning to end of each paving lane, except for inadvertent equipment breakdown. Backing the paver and refinishing a lane is not permitted. Remove and replace concrete refinished in this manner. Failure to achieve a continuous forward motion requires halting operations, and modifying procedures, equipment, or mix proportions to achieve this requirement. Personnel are not permitted to walk or operate in the plastic concrete at any time. Select paving equipment and procedures which operate properly on the underlying material without causing displacement or other damage.

3.5.2 Consolidation

Consolidate concrete with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. Insert vibrators into the concrete to a depth that provides the best full-depth consolidation but not closer to the underlying material than 2 inches. Excessive vibration is not permitted. If vibrators cause visible tracking in the paving lane, discontinue paving operations until equipment and operations have been modified to prevent it. Consolidate concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Do not use vibrators to transport or spread the concrete. Do not operate hand-operated vibrators in the concrete at one location for more than 20 seconds. Insert hand-operated vibrators between 6 to 15 inches on centers. For each paving train, provide at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) requires the immediate stopping of the paving operation and approved adjustment of the equipment or procedures.

3.5.3 Operation

When the paver approaches a header at the end of a paving lane, maintain a sufficient amount of concrete ahead of the paver to provide a roll of concrete which spills over the header. Provide a sufficient amount of extra concrete to prevent any grout that is formed and carried along ahead of the paver from being deposited adjacent to the header. Maintain the spud vibrators in front of the paver at the desired depth as close to the header as possible before they are lifted. Provide additional

consolidation adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provide provisions to prevent damage to the adjacent pavement. Electronically control screeds or extrusion plates so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. Maintain the overlapping area of existing pavement surface completely free of any loose or bonded foreign material as the paver-finisher operates across it. Pavers using transversely oscillating screeds are not allowed to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

Adjust and coordinate the paver-finisher, its gang-mounted vibrators, and operating procedures with the concrete mixture being used, to produce a thoroughly consolidated slab throughout that is true to line and grade within specified tolerances. Provide a paver-finishing operation that produces a surface finish with a minimum, isolated amount of irregularities, tears, voids of any kind, and any other discontinuities in a single pass across the pavement; multiple passes are not permitted. Provide equipment and its operation that produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. Stop paving if any equipment or operation fails to produce the above results. Prior to recommencing paving, properly adjust or replace the equipment, modify the operation, or modify the mixture proportions, in order to produce the required results. No water, other than fog sprays (mist) as specified in paragraph Prevention Of Plastic Shrinkage Cracking above, is allowed to be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

Provide paving equipment for fixed-form paving and operation that conforms to the requirements of paragraph EQUIPMENT, and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

- a. Provide straight forms made of steel and in sections not less than 10 feet in length that are clean and free of rust or other contaminants. Seal any holes or perforations in forms prior to paving unless otherwise permitted. Maintain forms in place and passable by all equipment necessary to complete the entire paving operation without need to remove horizontal form supports. Provide flexible or curved forms of proper radius for curves of 100-foot radius or less. Provide wood forms for curves and fillets made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend that have adequate strength and are rigidly braced. Provide forms with a depth equal to the pavement thickness at the edge. Where the project requires several different slab thicknesses, build up forms by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. Provide forms with the base width of the one-piece or built-up form not less than eight-tenths of the vertical height of the form, except provide forms 8 inches or less in vertical height with a base width not less than the vertical height of the form. Provide forms with maximum vertical deviation of top of any side form,

including joints, not varying from a true plane more than $\frac{1}{8}$ inch in 10 feet, and the upstanding leg not varying more than $\frac{1}{4}$ inch.

- b. Provide form sections that are tightly locked and free from play or movement in any direction. Provide forms with adequate devices for secure settings so that when in place they withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.
- c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, consolidation, and finishing so that forms do not deviate vertically more than 0.01 foot from required grade and elevations indicated. Check conformity to the alignment and grade elevations shown on the drawings and make necessary corrections immediately prior to placing the concrete. Clean and oil the forms each time before concrete is placed. Concrete placement is not allowed until setting of forms has been checked and approved by the CQC team.
- d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time. Remove forms by procedures that do not damage the concrete. Do not use bars or heavy metal tools directly against the concrete in removing the forms. Promptly repair any concrete found to be defective after form removal, using procedures specified or as directed.

3.5.6 Placing Reinforcing Steel

Provide the type and amount of steel reinforcement indicated. Regardless of placement procedure, provide reinforcing steel free from coatings which could impair bond between the steel and concrete, with reinforcement laps as indicated. Regardless of the equipment or procedures used for installing reinforcement, adequately consolidate the entire depth of concrete. Install steel reinforcement at the required elevation within a tolerance of plus or minus $\frac{1}{2}$ inch.

3.5.6.1 Pavement Thickness Less Than 12 Inches

For pavements less than 12 inches thick, position the reinforcement on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Consolidate concrete after the steel has been placed.

3.5.7 Placing Dowels and Tie Bars

Provide a method to install and hold dowels in position that meets the tolerances for location, alignment, and spacing of Table 15. Do not place longitudinal dowels and tie bars closer than 0.6 times the dowel bar length to the planned joint line. If the last regularly spaced longitudinal dowel is closer than that dimension, move it away from the joint to a location 0.6 times the dowel bar length, but not closer than 6 inches to its nearest neighbor. Resolve dowel interference at a

transverse joint-longitudinal joint intersection by deleting the closest transverse dowel . Do not position the end of a transverse dowel closer than 12 inches from the end of the nearest longitudinal dowel. Install dowels as specified in the following subparagraphs.

TABLE 15	
DOWEL ALIGNMENT TOLERANCES	
Dowel Measurement	Tolerance
Horizontal alignment (a)	Maximum of 1/8 inch per foot after the pavement has been completed
Vertical alignment (b)	Maximum of 1/8 inch per foot after the pavement has been completed
Horizontal spacing	plus or minus 5/8 inch, except as otherwise specified above
Vertical location on the face of the slab	plus or minus 1/2 inch
(a) Check horizontal alignment perpendicular to the joint edge with a framing square.	
(b) Measure the vertical alignment of the dowels parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Measure dowels across crowns and other joints at grade changes to a level surface.	

3.5.7.1 Contraction Joints

Securely hold dowels and tie bars in longitudinal and transverse contraction joints within the paving lane in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. Securely hold the basket assemblies in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires.

3.5.7.2 Construction Joints-Fixed Form Paving

Install dowels and tie bars by the bonded-in-place method or the drill-and-dowel method. Installation by removing and replacing in preformed holes is not permitted. Prepare and place dowels and tie bars across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. Provide the spacing of dowels and tie bars in construction joints as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, provide closer spacing with additional dowels or tie bars.

3.5.7.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes

drilled into the hardened concrete. Before drilling commences, cure the concrete for 7 days or until it has reached a minimum field cured compressive strength of 2500 psi. Drill holes 1/8 inch greater in diameter than the dowels into the hardened concrete using rotary-core drills. Rotary-percussion drills are permitted, provided that excessive spalling does not occur at the concrete joint face. Excessive spalling is defined as spalling deeper than 1/4 inch from the joint face or 1/2 inch radially from the outside of the drilled hole. Continuing damage requires modification of the equipment and operation. Drill depth of dowel hole within a tolerance of plus or minus 1/2 inch of the half length of the embedded dowel. Upon completion of the drilling operation, blow out the dowel hole with oil-free, compressed air. Bond dowels in the drilled holes using epoxy resin. Inject epoxy resin at the back of the hole before installing the dowel and extrude to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel is not permitted. Hold the dowels in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Provide dowels required between new and existing concrete in holes drilled in the existing concrete, all as specified above. Do not install tie bars in preformed holes. Construct a standard keyway, with the bent tie bars inserted into the plastic concrete through a 26 gauge thick metal keyway liner. Protect and maintain the keyway liner to remain in place and become part of the joint. When bending tie bars, provide the radius of bend not greater than the minimum recommended for the particular grade of steel in the appropriate material standard. Before placement of the adjoining paving lane, straighten the tie bars using procedures which do not spall the concrete around the bar.

3.5.7.4 Lubricating Dowel Bars

Wipe clean the portion of each dowel intended to move within the concrete and coat with a thin, even film of lubricating oil or light grease before the concrete is placed. Form oil is not acceptable.

3.6 FINISHING

Provide finishing operations as a continuing part of placing operations starting immediately behind the paver. Provide finishing by the machine method. Hand finishing requirements are specified in paragraph HAND FINISHING. Provide the sequence of operations consisting of transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Provide a work bridge as necessary for consolidation and hand finishing operations. Use the hand method only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Keep supplemental hand finishing for machine finished pavement to an absolute minimum. Immediately stop any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing. Prior to recommencing machine finishing, properly adjust or replace the equipment. Immediately halt any operations which produce more than 1/8 inch of mortar-rich surface (defined in paragraph Weak Surfaces) and modify the equipment, mixture, or procedures as necessary. Compensate for surging behind the screeds or extrusion plate and settlement during hardening and adjust the paving and finishing machines so that the finished surface of the concrete (not just the cutting edges of the screeds) is at the required line and grade. Maintain finishing equipment and tools clean and in an approved condition. Water is not allowed to be added to the surface of the slab with the finishing equipment or tools, or

in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

Replace machines that cause displacement of the forms. Only one pass of the fixed form finishing machine is allowed over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, immediately stop the operation and adjust the equipment, mixture, and procedures as necessary.

3.6.2 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, eliminate minor irregularities and score marks in the pavement surface by means of cutting straightedges. Provide cutting straightedges with a minimum length of 12 feet that are operated from the sides of the pavement or from bridges. Provide cutting straightedges operated from the side of the pavement equipped with a handle 3 feet longer than one-half the width of the pavement. Test the surface for trueness with a straightedge held in successive positions parallel and at right angles to the center line of the pavement, and cover the whole area to detect variations. Advance the straightedge along the pavement in successive stages of not more than one-half the length of the straightedge. Immediately fill depressions with freshly mixed concrete, strike off, consolidate with an internal vibrator, and refinish. Strike off projections above the required elevation and refinish. Continue the straightedge testing and finishing until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph SURFACE SMOOTHNESS. This straightedging is not allowed to be used as a replacement for the straightedge testing of paragraph SURFACE SMOOTHNESS. Use long-handled, flat bull floats very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, stop the paving operation and adjust the equipment, mixture or procedures to eliminate the surface defects. Keep finishing with hand floats and trowels to the absolute minimum necessary. Take extreme care to prevent overfinishing joints and edges. Produce the surface finish of the pavement essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations are subject to approval.

3.6.3 Hand Finishing

Use hand finishing operations only as specified below. Provide a work bridge to be used as necessary for consolidation and placement operations to avoid standing in concrete.

3.6.3.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. Provide a template at least 1 foot longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, that is constructed of metal or other suitable material shod with metal. Provide a longitudinal float at least 10 feet long, of approved design, that is rigid and substantially braced to maintain a plane surface on the bottom. Grate tampers (jitterbugs) are not allowed.

3.6.3.2 Finishing and Floating

As soon as the plastic concrete is placed and consolidated, strike off the concrete and screed to the cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement is at the required elevation. Immediately following the final tamping of the surface, float the pavement longitudinally from bridges resting on the side forms and spanning but not touching the concrete. Do not advance the floating operation more than half the length of the float and continue over the new and previously floated surfaces.

3.6.4 Texturing

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, texture the surface of the pavement as described herein. After the curing period is complete, thoroughly power broom all textured surfaces to remove all debris.

3.6.4.1 Burlap Drag Surface

Apply surface texture by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. Operate the drag with the fabric moist, and maintain the fabric clean. Change as required to keep clean. Perform the dragging so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.4.2 Broom Texturing

Complete brooming before the concrete has hardened to the point where the surface is unduly torn or roughened, but after hardening has progressed enough so that the mortar does not flow and reduce the sharpness of the scores. Overlap successive passes of the broom the minimum necessary to obtain a uniformly textured surface. Wash brooms thoroughly at frequent intervals during use. Remove worn or damaged brooms from the job site. Hand brooming is permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, provide brooms with handles longer than half the width of slab to be finished. Transversely draw the hand brooms across the surface from the center line to each edge with slight overlapping strokes.

3.6.5 Edging

Before texturing has been completed, carefully finish the edge of the slabs along the forms and at the joints with an edging tool to form a smooth rounded surface of $1/8$ inch radius. Eliminate tool marks, and provide edges that are smooth and true to line. Water is not allowed to be added to the surface during edging. Take extreme care to prevent overworking the concrete.

3.6.6 Pavement Penetrations

Construct recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement to conform to the details and dimensions shown. Carefully finish the concrete in these areas to provide a surface of the same texture as the surrounding area that is within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Continuously protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. Have all equipment needed for adequate curing and protection of the concrete on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, remove or replace the damaged pavement, and provide another method of curing as directed. Accomplish curing by one of the following methods. .

3.7.2 Membrane Curing

Apply a uniform coating of white-pigmented, membrane-forming, curing compound to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing . Apply immediately along the formed edge faces after the forms are removed. Do not allow the concrete to dry before the application of the membrane. If any drying has occurred, moisten the surface of the concrete with a fine spray of water, and apply the curing compound as soon as the free water disappears. Apply the curing compound to the finished surfaces by means of an approved automatic spraying machine. Apply the curing compound with an overlapping coverage that provides a two-coat application at a coverage of 400 square feet per gallon, plus or minus 5.0 percent for each coat. A one-coat application is allowed provided it is applied in a uniform application and coverage of 200 square feet per gallon, plus or minus 5.0 percent is obtained. The application of curing compound by hand-operated, mechanical powered pressure sprayers is permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, apply a second coat in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray curing compound to concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied. Within the curing period, immediately respray areas where the curing compound is damaged by subsequent construction operations. During the entire curing period, adequately protect membrane-cured concrete surfaces from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.8 JOINTS

3.8.1 General Requirements for Joints

Construct joints that conform to the locations and details indicated and are perpendicular to the finished grade of the pavement. Provide joints that are straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 1/2 inch. Where any joint fails to meet these tolerances, remove and replace the slabs adjacent to the joint at no additional cost to the Government. Changes from the jointing pattern shown on the drawings are not allowed without written approval. Seal joints immediately following curing of the concrete or as soon thereafter as weather conditions permit as specified in Section 32 01 19.61 SEALING OF JOINTS IN RIGID PAVEMENT .

3.8.2 Longitudinal Construction Joints

Install dowels or tie bars in the longitudinal construction joints, or thicken the edges as indicated. Install dowels and tie bars as specified above. After the end of the curing period, saw longitudinal construction joints to provide a reservoir at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Install transverse construction joints at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. Provide transverse construction joints by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Construct pavement with the paver as close to the header as possible, with the paver run out completely past the header. Provide transverse construction joints at a planned transverse joint constructed as shown or, if not shown otherwise, dowelled in accordance with paragraph DOWELS INSTALLED IN HARDENED CONCRETE, or paragraph FIXED FORM PAVING above.

3.8.4 Expansion Joints

Provide expansion joints where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and installed to form a complete, uniform separation between the structure and the pavement or between two pavements. Attach the filler to the original concrete placement with adhesive and mechanical fasteners and extending to the full slab depth. Tightly fit adjacent sections of filler together, with the filler extending across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Finish edges of the concrete at the joint face with an edger with a radius of 1/8 inch. After placement and curing of the adjacent slab, sawcut the sealant reservoir depth from the filler.

3.8.5 Contraction Joints

Construct transverse and longitudinal contraction joints by an initial sawcut in the concrete with a 1/8 inch blade to the indicated depth. During sawing of joints, and again 24 hours later, inspect all exposed lane edges for development of cracks below the saw cut, and immediately report results. If there are more than six consecutive uncracked joints after 48 hours, saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. Vary the time of initial sawing depending on existing and anticipated weather conditions to prevent uncontrolled cracking of the pavement. Commence sawing of the joints as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. Inspect the sawed faces of joints for undercutting or washing of the concrete due to the early sawing, and delay sawing if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. Continue the sawing operation as required during both day and night regardless of weather conditions. Saw the joints in the sequence of the concrete placement. Provide adequate lighting for night work. Illumination using vehicle headlights is not permitted. Provide a chalk line or other suitable guide to mark the alignment of the joint. Before sawing a joint, examine the concrete closely for cracks, and do not saw the joint if a crack has occurred near the planned joint location. Discontinue sawing if

a crack develops ahead of the saw cut. Immediately after the joint is sawed, thoroughly flush the saw cut and adjacent concrete surface with water and vacuum until all waste from sawing is removed from the joint and adjacent concrete surface. Properly protect the concrete from damage and cure at sawed joints. Tightly seal the top of the joint opening and the joint groove at exposed edges with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and maintain until removed immediately before sawing the joint sealant reservoir. Respray the surface with curing compound as soon as free water disappears. Seal the exposed saw cuts on the vertical faces of pilot lanes with bituminous mastic or masking tape. After expiration of the curing period, widen the upper portion of the groove by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. Center the reservoir over the initial sawcut.

3.8.6 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Grade the underlying material in the transition area as shown and meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

Repair or remove and replace new pavement slabs as specified at no cost to the Government. Removal of partial slabs is not permitted. Prior to any repairs, submit a [Repair Recommendations Plan](#) detailing areas exceeding the specified limits as well as repair recommendations required to bring these areas within specified tolerances.

3.9.2 Repair of Free Edge Lane Vertical Faces

Repair excessive edge slump and joint face deformation while concrete is in a plastic state by approved methods using forms in accordance with paragraph Forms for Fixed-Form Paving.

3.9.3 Slabs with Cracks

The Government may require cores to be taken over cracks to determine depth of cracking. Drill cores with a minimum diameter of [6 inches](#), and backfill with an approved concrete mixture. Perform drilling of cores and filling of holes at no expense to the Government. Clean cracks that do not exceed [2 inches](#) in depth; then pressure inject full depth with epoxy resin, Type IV, Grade 1. Remove and replace slabs containing cracks deeper than [2 inches](#).

3.9.4 Removal and Replacement of Full Slabs

Remove new or existing slabs damaged during construction that contain more than 15.0 percent of each longitudinal or transverse joint edge spalled. Where it is necessary to remove full slabs, remove in accordance with paragraph Removal Of Existing Pavement Slab below. Remove and replace full depth, by full width of the slab, and extend to each original joint. Compact and shape the underlying material as specified in the appropriate section of these specifications, clean the surfaces of all four joint faces of all loose material and contaminants, and coat with a double application of membrane forming curing compound as a bond breaker

and to protect concrete that has not been cured for at least 7 days. Install dowels of the size and spacing as specified for other joints in similar pavement by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph PLACING DOWELS AND TIE BARS, above. Provide dowels for all four edges of the new slab. Cut off original damaged dowels or tie bars flush with the joint face. Lightly oil or grease protruding portions of new dowels. Place concrete as specified for original construction. Take care to prevent any curing compound from contacting dowels or tie bars. Prepare and seal the resulting joints around the new slab as specified for original construction.

3.9.5 Repairing Spalls Along Joints

Repair spalls along joints to be sealed to a depth to restore the full joint-face support prior to placing adjacent pavement. Where directed, repair spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks by first making a vertical saw cut at least 3 inches outside the spalled area and to a depth of at least 2 inches. Provide saw cuts consisting of straight lines forming rectangular areas without sawing beyond the intersecting saw cut. Chip out the concrete between the saw cut and the joint, or crack, to remove all unsound concrete and into at least 1/2 inch of visually sound concrete. Thoroughly clean the cavity thus formed with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, apply a prime coat to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. Apply the prime coat in a thin coating and scrub into the surface with a stiff-bristle brush. Provide prime coat for portland cement repairs consisting of a neat cement grout and for epoxy resin repairs consisting of epoxy resin, Type III, Grade 1. Fill the prepared cavity with material identified in Table 16 based on the cavity volume.

TABLE 16	
SPALL REPAIRS	
Volume of Prepared Cavity After Removal Operations	Material
less than 0.03 cubic foot	epoxy resin mortar or epoxy resin or latex modified mortar
0.03 cubic foot and 1/3 cubic foot	portland cement mortar
more than 1/3 cubic foot	portland cement concrete or latex modified mortar

Provide portland cement concretes and mortars that consist of very low slump mixtures, 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Provide epoxy resin mortars made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved. Proprietary patching materials may be used, subject to Government approval. Place the epoxy resin materials in the cavity in layers with a maximum thickness of 2 inches. Provide adequate time between placement of additional layers such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during

hardening. Provide mechanical vibrators and hand tampers to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens. Where the spalled area abuts a joint, provide an insert or other bond-breaking medium to prevent bond at the joint face. For existing joints, seal the bottom contraction crack with backer rod to prevent intrusion of primer or mortar. Saw a reservoir for the joint sealant to the dimensions required for other joints. Thoroughly clean the reservoir and then seal with the sealer specified for the joints. In lieu of sawing, spalls and popouts, less than 6 inches in maximum dimension and not adjacent to a joint, may be prepared by drilling a core 2 inches in diameter greater than the size of the defect, centered over the defect, and 2 inches deep or 1/2 inch into sound concrete, whichever is greater. Repair the core hole as specified above for other spalls.

3.9.6 Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Rain damaged pavement is pavement with coarse aggregate exposed at the surface. Cores evaluated by a qualified petrographer to contain carbonation to a depth greater than 1/8 inch or Mohs hardness of less than 2, when tested in accordance with ASTM C1895, are also considered rain damaged. A mortar-rich surface is defined as pavement deficient in plus 4.75 mm U.S. No. 4 sieve size aggregate. Diamond grind slabs containing weak surfaces less than 1/4 inch thick to remove the weak surface. Diamond grind in accordance with paragraph Diamond Grinding Of PCC Surfaces. All diamond ground areas are required to meet the thickness, smoothness and plan grade criteria specified in PART 1 GENERAL. Remove and replace slabs containing weak surfaces greater than 1/4 inch thick.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Demolition of existing operational pavement is not allowed prior to approval of the Proportioning Studies. Remove existing concrete pavement at locations indicated on the drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, survey the remaining edge again to quantify any damage caused by removal operations. Perform both surveys in the presence of the Government. Perform repairs as indicated and as specified herein. Carefully control all operations to prevent damage to the concrete pavement and to the underlying material to remain in place. Perform all saw cuts perpendicular to the slab surface, forming rectangular areas. Perform all existing concrete pavement repairs prior to paving adjacent lanes.

3.10.1 Removal of Existing Pavement Slab

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, perform the first full depth saw cut on the joint between the removal area and adjoining pavement to stay in place with a standard diamond-type concrete saw. Next, perform a full depth saw cut parallel to the joint that is at least 24 inches from the joint and at least 6 inches from the end of any dowels with a wheel saw as specified in paragraph SAWING EQUIPMENT. Remove all pavement beyond this last saw cut in accordance with the approved demolition work plan. Remove all pavement between this last saw cut and the joint line by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of

concrete may be carefully broken up and removed using hand-held jackhammers, 30 lb or less, or other approved light-duty equipment which does not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Use suitable equipment to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

Protect the edge of existing concrete pavement against which new pavement abuts from damage at all times. Remove and replace slabs which are damaged during construction as directed at no cost to the Government. Repair of previously existing damaged areas is considered a subsidiary part of concrete pavement construction. Saw off all exposed keys and keyways full depth.

3.10.2.1 Spall Repair

Repair spalls caused by construction activities if less than 15.0 percent of any slab's edge. Provide repair materials and procedures as previously specified in paragraph, Repairing Spalls Along Joints. Remove and replace full slabs if spalls exceed 15.0 percent of any slab's edge as specified in paragraph, Removal and Replacement of Full Slabs.

3.10.2.2 Underbreak and Underlying Material

Repair all underbreak by removal and replacement of the damaged slabs in accordance with paragraph REMOVAL AND REPLACEMENT OF FULL SLABS above. Protect the underlying material adjacent to the edge of and under the existing pavement which is to remain from damage or disturbance during removal operations and until placement of new concrete, and shape as directed. Maintain sufficient underlying material in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Remove and replace any slab with underlying material that is disturbed or loses its compaction.

3.11 PAVEMENT PROTECTION

Exclude traffic from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment is permitted on the new pavement after the pavement has been cured for 7 days, the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured and approved means are provided to prevent damage to the slab edge. Fabricate and field cure specimens in accordance with ASTM C31/C31M. Continuously maintain all new and existing pavement carrying construction traffic or equipment completely clean, and clean up spillage of concrete or other materials immediately upon occurrence. Take special care in areas where traffic uses or crosses active airfield pavement. Power broom other existing pavements at least daily when traffic operates. For fill-in lanes, provide equipment that does not damage or spall the edges or joints of the previously constructed pavement. Protect the pavement against all damage prior to final acceptance of the work by the Government. Placement of aggregates, rubble, or other similar construction materials on airfield pavements is not allowed.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION

3.12.1 Testing and Inspection by Contractor

During construction, perform sampling and testing of aggregates, cementitious materials (cement, slag cement, and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Obtain samples of concrete at the point of delivery to the paver. Testing by the Government in no way relieves the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. Perform this testing regardless of any other testing performed by the Government, either for pay adjustment purposes or for any other reason. Include stationing for all sampling and testing.

3.12.2 Testing and Inspection Requirements

Perform CQC sampling, testing, inspection and reporting in accordance with the following Table. Retest aggregate sources and stockpiles in accordance with Table 17 if not used within the previous 3 months.

TABLE 17			
TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
<u>Fine Aggregate Gradation and Fineness Modulus</u>			
2 per lot	ASTM C136/C136M sample at belt	9 of 10 tests vary less than 0.15 from average	Retest, resolve, retest
		Outside limits on any sieve	Retest
		2nd gradation failure	Stop, resolve, retest
1 per 10 gradations	ASTM C117	Outside limits on any sieve	Retest
		2nd gradation failure	Stop, repair, retest
<u>Coarse Aggregate Gradation (each aggregate size)</u>			

TABLE 17			
TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
2 per lot	ASTM C136/C136M sample at belt	Outside limits on any sieve	Retest
		2nd gradation failure	report to COR, correct
		2 consecutive averages of 5 tests outside limits	report to COR, stop ops, repair, retest
1 per 10 gradations	ASTM C117	Outside limits on any sieve	Retest
		2nd gradation failure	report to COR, correct
		2 consecutive averages of 5 tests outside limits	report to COR, stop ops, repair, reverify all operations
Workability Factor and Coarseness Factor Computation			
Same as C.A. and F.A.	see paragraph AGGREGATES	Use individual C.A. and F.A. gradations. Combine using batch ticket percentages (average of aggregate percentages from 3 before and 3 after sampling). Tolerances: plus or minus 3 points on WF; plus or minus 5 points on CF from approved adjusted mix design values; only the portion of the tolerance box within the parallelogram is available for use	Check batching tolerances, recalibrate scales
		2 consecutive averages of 5 tests outside limits	Stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Aggregate Deleterious, Quality, and ASR Tests			

TABLE 17			
TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
Every 30 days of concrete production	see paragraph AGGREGATES		Stop production, retest, replace aggregate. Increase testing interval to 90 days if previous 2 tests pass
<u>Plant - Scales, Weighing Accuracy</u>			
Monthly	NRMCA QC 3		Stop plant ops, repair, recalibrate
<u>Plant - Batching and Recording Accuracy</u>			
Weekly	Record/Report	Record required/recorded/actual batch mass	Stop plant ops, repair, recalibrate
<u>Plant - Batch Plant Control</u>			
Every lot	Record/Report		Record type and amount of each material per lot
<u>Plant - Mixer Uniformity - Stationary Mixers</u>			
Every 4 months during paving	COE CRD-C 55	After initial approval, use abbreviated method	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
<u>Plant - Mixer Uniformity - Truck Mixers</u>			
Every 4 months during paving	ASTM C94/C94M	Random selection of truck.	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
<u>Concrete Mixture - Air Content</u>			

TABLE 17			
TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
When test specimens prepared plus 2 random per lot	ASTM C231/C231M sample at point of discharge within the paving lane	Individual test control chart: Warning plus or minus 1.0	Adjust AEA, retest
		Individual test control chart: Action plus or minus 1.5	Halt operations, repair, retest
		Range between 2 consecutive tests: Warning plus 2.0	Recalibrate AEA dispenser
		Range between 2 consecutive tests: Action plus 3.0	Halt operations, repair, retest
Concrete Mixture - Unit Weight and Yield			
Same as Air Content	ASTM C138/C138M sample at point of discharge within the paving lane	Individual test basis: Warning Yield minus 0 or plus 1 percent	Check batching tolerances
		Individual test basis: Action Yield minus 0 or plus 5 percent	Halt operations
Concrete Mixture - Slump			
When test specimens prepared plus 4 random per lot	ASTM C143/C143M sample at point of discharge within the paving lane	Individual test control chart: Upper Warning fixed form 1.5 inches hand placement 2.5 inches	Adjust batch masses within max W/C ratio
		Individual test control chart: Upper Action at maximum allowable slump	Stop operations, adjust, retest
		Range between each consecutive test: 1-1/2 inches	Stop operations, repair, retest
Concrete Mixture - Temperature			

TABLE 17			
TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
When test specimens prepared	ASTM C1064/C1064M sample at point of discharge within the paving lane	See paragraph WEATHER LIMITATIONS	
Concrete Mixture - Strength			
8 per lot	ASTM C31/C31M sample at point of discharge within the paving lane	See paragraph CONCRETE STRENGTH TESTING for CQC Perform fabrication of strength specimens and initial cure outside the paving lane and within 1,000 feet of the sampling point.	
Paving - Inspection Before Paving			
Prior to each paving operation	Report	Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items	
Paving - Inspection During Paving			
During paving operation		Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.	
Paving - Vibrators			
Weekly during paving	COE CRD-C 521	Test frequency (in concrete), and amplitude (in air), average measurement at tip and head.	Repair or replace defective vibrators.
Moist Curing			
2 per lot, min 4 per day	Visual		Repair defects, extend curing by 1 day
Membrane Compound Curing			

TABLE 17			
TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
Daily	Visual	Calculate coverage based on quantity/area	Respray areas where coverage defective. Recalibrate equipment
<u>Cold Weather Protection</u>			
Once per day	Visual		Repair defects, report conditions to COR

3.12.3 Control Charts

Maintain linear control charts for fine and coarse aggregate gradation, combined gradation coarseness factor/workability factor, slump, air content, unit weight, yield, and 7 and 14 day flexural strengths.

Post the control charts as directed and maintain current at all times. Identify the following on the control charts: the project number, the test parameter being plotted, the individual sample numbers, the Warning and Action Limits listed in Table 17 applicable to the test parameter being plotted, and the test results. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts.

3.12.4 Concrete Strength Testing for CQC

Perform Contractor Quality Control operations for concrete strength consisting of the following steps:

- a. Take samples for strength tests at the paving site. Fabricate and cure test cylinders in accordance with ASTM C31/C31M; test them in accordance with ASTM C39/C39M.

- b. Fabricate and cure 2 test cylinders per subplot from the same batch or truckload and at the same time acceptance cylinders are fabricated and test them for compressive strength at 7-day age.
- c. Average all 8 compressive tests per lot. Convert this average 7-day compressive strength per lot to equivalent 90-day flexural strength using the Correlation Ratio determined during mixture proportioning studies.
- d. Compare the equivalent 90-day flexural strength from the conversion to the required average CQC flexural strength, Ra.
- e. If the equivalent average 90-day strength for the lot is below the required average CQC flexural strength, Ra, by 20 psi flexural strength or more, at any time, adjust the mixture to increase the strength, as approved.
- f. Fabricate and cure two beams for every 2000 cubic yards of concrete placed. Fabricate and cure in accordance with ASTM C31/C31M; test at 14-days of age in accordance with ASTM C78/C78M. Use the flexural strength results to verify the cylinder-beam acceptance correlation ratio.
- g. Maintain up-to-date control charts for strength, showing the 7-day CQC compressive strength, the 14-day compressive strength (from acceptance tests) and the 90-day equivalent flexural strength of each of these for each lot.

3.12.5 Reports

Report all results of tests or inspections conducted as they are completed and in writing daily. Post updated control charts and identify accepted paving lots on the detailed paving sequence paving plan covering the entire period from the start of paving through the current week. These requirements do not relieve the obligation to report failures immediately as required in preceding paragraphs and Section 01 45 00.00 10 QUALITY CONTROL. Confirm reports of failures and the corrective action taken in writing in the daily Quality Control reports and within each respective Paving Lot Report. Compile, reduce, analyze and compute pay adjustment factors for all associated test data collected on each paving lot.

At a minimum, include a narrative in each Paving Lot Report addressing success, failures, and process control changes necessary to meet specified tolerances. Identify subject paving lot on the detailed paving sequence plan and label lots and sublots and their stationing. Provide a summary of payment adjustment factors and pass/fail test for each paving lot constructed. Submit complete and comprehensive Paving Lot Reports for the test section and production paving within 16 days after the completion of the placement. Do not place adjacent or contiguous lane/lot prior to receiving approval for the placed pavement. Organize each Paving Lot Report by the following specific items. The list below is not all inclusive. Add tests and inspections as appropriate for each specific paving lot constructed.

- a. Underlying material test results reference to previous submittal numbers.
- b. Batch Plant stockpile management and constituent tolerances.
- c. Batching and Paving Equipment Issues.

- d. Reinforcing, embeds and block-outs.
- e. Actual Conditions, and Protection Means: Rain, Cold, Hot and/or windy conditions including evaporation rates, high/low ambient temperature.
- f. PCC Plastic Mixture Properties.
- g. Batch tickets. Provide legible copies.
- h. Strength specimens initial cure: location, temperatures.
- i. Aggregate gradation test results.
- j. Finishing: cutting straight-edge, automatic longitudinal float, edging tool, minimal hand work and excess paste.
- k. Texturing operation.
- l. Curing operation: equipment calibration, wet cure, membrane cure or both.
- m. Initial saw cutting (early entry or wet diamond, flushing and vacuuming, backer rod installation and reapplication of curing compound).
- n. Dowel installation and alignment results .
- o. Surface Smoothness in both longitudinal and transverse directions (if diamond grinding occurs, retest and include results).
- p. Edge Slump (excessive, lost and rebuilt edge).
- q. Joint Face Deformation (cutting or diamond grinding).
- r. Plan Grade: table providing x, y, and elevation values versus design values.
- s. Strength: beam/cylinder strength results (with updated correlation ratios and control chart).
- t. Evaluation of cores.
- u. Post-Production Pavement Protection Measures: protection and traffic control.
- v. Fixed Forms (as applicable).

-- End of Section --

SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 182 (2005; R 2017) Standard Specification for
Burlap Cloth Made from Jute or Kenaf and
Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M (2022) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement

ASTM A1064/A1064M (2022) Standard Specification for
Carbon-Steel Wire and Welded Wire
Reinforcement, Plain and Deformed, for
Concrete

ASTM C31/C31M (2023) Standard Practice for Making and
Curing Concrete Test Specimens in the Field

ASTM C143/C143M (2020) Standard Test Method for Slump of
Hydraulic-Cement Concrete

ASTM C171 (2020) Standard Specification for Sheet
Materials for Curing Concrete

ASTM C172/C172M (2017) Standard Practice for Sampling
Freshly Mixed Concrete

ASTM C173/C173M (2016) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Volumetric Method

ASTM C231/C231M (2022) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Pressure Method

ASTM C309 (2019) Standard Specification for Liquid
Membrane-Forming Compounds for Curing
Concrete

ASTM C920 (2018) Standard Specification for
Elastomeric Joint Sealants

ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

Biodegradable Form Release Agent

SD-06 Test Reports

Field Quality Control

1.3 EQUIPMENT, TOOLS, AND MACHINES

1.3.1 General Requirements

Plant, equipment, machines, and tools used in the work will be subject to approval and must be maintained in a satisfactory working condition at all times. Use equipment capable of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Discontinue using equipment that produces unsatisfactory results. Allow the Contracting Officer access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.3.2 Slip Form Equipment

Slip form paver or curb forming machines, will be approved based on trial use on the job and must be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass.

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement and protection must be approved in writing. Approval will be contingent upon full conformance with the following provisions. Prepare and protect the underlying material so that it is entirely free of frost when the concrete is deposited. Heat mixing water and aggregates as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating must be approved. Use only aggregates that are free of ice, snow, and frozen lumps before entering the mixer. Provide covering or other means as needed to maintain the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE except as otherwise specified. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an air content by volume of concrete of 2 to 5 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

Use concrete with a slump of 3 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to [ASTM C171](#), type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to [AASHTO M 182](#).

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to [ASTM C309](#), Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Unless otherwise indicated, use [1/2 inch](#) thick premolded expansion joint filler conforming to [ASTM D1751](#) or [ASTM D1752](#).

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to [ASTM C920](#) or [ASTM D5893/D5893M](#).

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, [2 inches](#) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of [10 feet](#). Radius bends may be formed with [3/4 inch](#) boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at each end and at not less than two intermediate points. Use forms with

interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 - Section 705.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Construct subgrade to the specified grade and cross section prior to concrete placement.

3.1.1 Sidewalk Subgrade

Place and compact the subgrade in accordance with Section 31 00 00 EARTHWORK . Test the subgrade for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

Place and compact the subgrade in accordance with Section 32 11 23 AGGREGATE BASE COURSE FOR FLEXIBLE PAVING. Test the subgrade for grade and cross section by means of a template extending the full width of the curb and gutter. Use subgrade materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

Maintain subgrade in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade must be in a moist condition when concrete is placed. Prepare and protect subgrade so that it is free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Use additional stakes and braces at corners, deep sections, and radius bends, as required. Use clamps, spreaders, and braces where required to ensure rigidity in the forms. Remove forms in a manner that will not injure the concrete. Do not use bars or heavy tools against the concrete when removing the forms. Promptly and satisfactorily repair concrete found to be defective after form removal. Clean forms and coat with form oil or biodegradable form release agent each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment must be checked with a 10 foot straightedge. Sidewalks must have a transverse slope as indicated. Do not remove side forms less than 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

Remove forms used along the front of the curb not less than 2 hours nor more than 6 hours after the concrete has been placed. Do not remove forms used along the back of curb until the face and top of the curb have been finished, as specified for concrete finishing. Do not remove gutter forms while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks must be of the thickness indicated. Use a strike-off guided by side forms after concrete has been placed in the forms to bring the surface to proper section to be compacted. Consolidate concrete by tamping and spading or with an approved vibrator. Finish the surface to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. Produce a scored surface by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

Finish all slab edges, including those at formed joints, with an edger having a radius of 1/8 inch. Edge transverse joints before brooming. Eliminate the flat surface left by the surface face of the edger with brooming. Clean and solidly fill corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing with a properly proportioned mortar mixture and then finish.

3.3.4 Surface and Thickness Tolerances

Finished surfaces must not vary more than $\frac{5}{16}$ inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to $\frac{1}{4}$ inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Place concrete to the required section in a single lift. Consolidate concrete using approved mechanical vibrators. Curve shaped gutters must be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Float and finish exposed surfaces with a smooth wood float until true to grade and section and uniform in texture. Brush floated surfaces with a fine-hair brush using longitudinal strokes. Round the edges of the gutter and top of the curb with an edging tool to a radius of $\frac{1}{2}$ inch. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the front curb surface, while still wet, in the same manner as the gutter and curb top. Finish the top surface of gutter and entrance to grade with a wood float.

3.4.4 Joint Finishing

Finish curb edges at formed joints as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces must not vary more than $\frac{1}{4}$ inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to $\frac{1}{4}$ inch.

3.5 SIDEWALK JOINTS

Construct sidewalk joints to divide the surface into rectangular areas. Space transverse contraction joints at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and continuous across the slab. Construct longitudinal contraction joints along the centerline of all sidewalks 10 feet or more in width. Construct transverse expansion joints at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, install transverse expansion joints as indicated. Form expansion joints around structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

Form contraction joints in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness. Unless otherwise approved or indicated, either use a jointer to cut the groove or saw a groove in the hardened concrete with a power-driven saw. Construct sawed joints by sawing a groove in the concrete with a $1/8$ inch blade. Provide an ample supply of saw blades on the jobsite before concrete placement is started. Provide at least one standby sawing unit in good working order at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Form expansion joints using $1/2$ inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Hold joint filler in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, round joint edges using an edging tool having a radius of $1/8$ inch. Remove any concrete over the joint filler. At the end of the curing period, clean the top of expansion joints and fill with cold-applied joint sealant. Use joint sealant that is gray or stone in color. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Apply joint sealing material only when the concrete at the joint is surface dry and atmospheric and concrete temperatures are above 50 degrees F. Immediately remove any excess material on exposed surfaces of the concrete and clean the concrete surfaces.

3.5.3 Reinforcement Steel Placement

Accurately and securely fasten reinforcement steel in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Construct curb and gutter joints at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Construct contraction joints directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

- a. Construct contraction joints (except for slip forming) by means of $1/8$ inch thick separators and of a section conforming to the cross section of the curb and gutter. Remove separators as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.
- b. When slip forming is used, cut the contraction joints in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. Cut the contraction joint to a depth of at least one-fourth of the gutter/curb depth using a $1/8$ inch saw blade.

3.6.2 Expansion Joints

Form expansion joints by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Construct expansion joints in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement using the same type and thickness of joints as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, provide expansion joints at least **1/2 inch** in width at intervals not less than **30 feet** nor greater than **120 feet**. Seal expansion joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal expansion joints and the top **1 inch** depth of curb and gutter contraction-joints with joint sealant. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Concrete at the joint must be surface dry and atmospheric and concrete temperatures must be above **50 degrees F** at the time of application of joint sealing material. Immediately remove excess material on exposed surfaces of the concrete and clean concrete surfaces.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete must be on hand and ready for use before actual concrete placement begins. Protect concrete as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least **6 inches**. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped **12 inches** when a continuous sheet is not used. Use sheeting that is not less than **18-inches** wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour

after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.7.4 Protective Coating

Apply a protective coating of linseed oil mixture to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Moist cure concrete to receive a protective coating.

3.7.4.1 Application

Complete curing and backfilling operation prior to applying two coats of protective coating. Concrete must be surface dry and clean before each application. Spray apply at a rate of not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each

application for commercially prepared mixture must be in accordance with the manufacturer's instructions. Protect coated surfaces from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Do not heat protective coating by direct application of flame or electrical heaters and protect the coating from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Do not apply material at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing foreman if results are out of tolerance. The placing foreman must take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Perform two slump tests on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Perform additional tests when excessive variation in the workability of the concrete is noted or when excessive

crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

Determine the anticipated thickness of the concrete prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, construct the subgrade true to grade prior to concrete placement. The thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

Provide finished surfaces for each category of the completed work that are uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than $\frac{1}{4}$ inch the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, reduce high areas either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete must not exceed 5 percent of the area of any integral slab, and the depth of grinding must not exceed $\frac{1}{4}$ inch. Remove and replace pavement areas requiring grade or surface smoothness corrections in excess of the limits specified.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Contracting Officer and deficiencies in appearance will be identified. Remove and replace areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work.

3.10 DETECTABLE WARNING SYSTEM

Install Detectable Warning Systems required by Contract plans in accordance with ICC A117.1, Section 705, and by manufacturers' installation instructions.

-- End of Section --

SECTION 32 17 23

PAVEMENT MARKINGS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 249 (2012; R2016) Standard Specification for
White and Yellow Reflective Thermoplastic
Striping Material (Solid Form)

ASTM INTERNATIONAL (ASTM)

ASTM D471 (2016a) Standard Test Method for Rubber
Property - Effect of Liquids

ASTM D522/D522M (2017) Mandrel Bend Test of Attached
Organic Coatings

ASTM D711 (2010; R 2015) No-Pick-Up Time of Traffic
Paint

ASTM D823 (2018) Standard Practices for Producing
Films of Uniform Thickness of Paint,
Coatings, and Related Products on Test
Panels

ASTM D2240 (2015; E 2017) Standard Test Method for
Rubber Property - Durometer Hardness

ASTM D2621 (1987; R 2016) Standard Test Method for
Infrared Identification of Vehicle Solids
from Solvent-Reducible Paints

ASTM D2697 (2003; R 2014) Volume Nonvolatile Matter
in Clear or Pigmented Coatings

ASTM D3335 (1985a; R 2020) Low Concentrations of
Lead, Cadmium, and Cobalt in Paint by
Atomic Absorption Spectroscopy

ASTM D3718 (1985a; R 2015) Low Concentrations of
Chromium in Paint by Atomic Absorption
Spectroscopy

ASTM D3924 (2016) Standard Specification for
Environment for Conditioning and Testing
Paint, Varnish, Lacquer, and Related
Materials

ASTM D3960	(2005; R 2013) Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4505	(2012; R 2017) Standard Specification for Preformed Retroflective Pavement Marking Tape for Extended Service Life
ASTM D4541	(2022) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D6628	(2003; R 2015) Standard Specification for Color of Pavement Marking Materials
ASTM G154	(2023) Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732	(1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009; Rev 2012) Manual on Uniform Traffic Control Devices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325	(Rev D; Notice 1; Notice 2 2017) Beads (Glass Spheres) Retro-Reflective (Metric)
FS TT-P-1952	(2015; Rev F; Notice 1) Paint, Traffic and Airfield Markings, Waterborne

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Surface Preparation Equipment List; G, R0

Application Equipment List; G, R0

Exterior Surface Preparation

Safety Data Sheets; G, R0

Reflective media for roads; G, R0

Waterborne Paint; G, R0

Thermoplastic compound; G, R0

SD-06 Test Reports

Reflective Media for Roads; G, R0

Waterborne Paint; G, R0

High Build Acrylic Coating (HBAC); G, R0

Thermoplastic Compound; G, R0

SD-07 Certificates

Qualifications; G, R0

Reflective Media for Roads

Waterborne Paint

Volatile Organic Compound, (VOC); G, R0

Thermoplastic Compound

SD-08 Manufacturer's Instructions

Waterborne Paint; G, R0

Thermoplastic Compound; G, R0

1.3 QUALITY ASSURANCE

1.3.1 Regulatory Requirements

Submit certificate stating that the proposed pavement marking paint meets the [Volatile Organic Compound](#), (VOC) regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located. Submit [Safety Data Sheets](#) for each product.

1.3.2 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.4 DELIVERY AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site for maintaining materials at temperatures recommended by the manufacturer.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Environmental Requirements

1.5.1.1 Weather Limitations for Application

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.

1.5.1.2 Weather Limitations for Removal of Pavement Markings on Roads and Automotive Parking Areas

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.5.2 Traffic Controls

Place warning signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

1.5.3 Lighting

When night operations are necessary, provide all necessary lighting and equipment. The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Surface Preparation and Paint Removal

2.1.1.1 Surface Preparation and Paint Removal Equipment for Airfield Pavements

Prepare all airfield surfaces and remove paint from airfield surfaces in accordance with UFGS 32 01 11.51 Rubber and Paint Removal From Airfield Pavements. Provide submittals in accordance with UFGS 32 01 11.51 Rubber and Paint Removal From Airfield Pavements.

2.1.1.2 Surface Preparation Equipment for Roads and Automotive Parking Areas

Submit a [surface preparation equipment list](#) by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1.2.1 Sandblasting Equipment

Use mobile sandblasting equipment capable of producing a pressurized stream of sand and air that effectively removes paint from the surface without filling voids with debris in asphalt or tar pavements or removing joint sealants in Portland cement concrete pavements. Include with the equipment and air compressor, hoses, and nozzles of adequate size and capacity for removing paint. Equip the compressor with traps and coalescing filters that maintain the compressed air free of oil and water.

2.1.1.2.2 Waterblasting Equipment

Use mobile waterblasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order at all times.

2.1.1.2.3 Grinding or Scarifying Equipment

Use equipment capable of removing surface contaminants, paint build-up, or extraneous markings from the pavement surface without leaving any residue. Clean the surface by hydro blast to remove surface contaminants and ash after a weed torch is used to remove paint.

2.1.1.2.4 Chemical Removal Equipment

Use chemical equipment capable of applying and removing chemicals and paint from the pavement surface, leaving only non-toxic biodegradable residue without scarring or other damage to the pavement or joints and joint seals.

2.1.2 Application Equipment

Submit [application equipment list](#) appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove them from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1 Paint Application Equipment

2.1.2.1.1 Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of water based paint or two-component, chemically curing paint, thermoplastic, or preformed tape, to pavement surfaces for small marking projects, such as legends and cross-walks, automotive parking areas, or surface painted signs. Provide applicator machine equipped with the necessary tanks and spraying nozzles capable of applying paint uniformly at coverage specified. Hand operated spray guns may be used in areas where push-type machines cannot be used.

2.1.2.2 Thermoplastic Application Equipment

2.1.2.2.1 Thermoplastic Material

Apply thermoplastic material with equipment that is capable of providing continuous uniformity in the dimensions and reflectorization of the marking.

2.1.2.2.2 Application Equipment

- a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts which prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. All parts of the equipment which come into contact with the material must be easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns must maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.
- b. Provide application equipment constructed to ensure continuous uniformity in the dimensions of the stripe. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying "skiplines." Provide equipment capable of applying varying widths of traffic markings.
- c. Provide mobile and maneuverable application equipment allowing straight lines to be followed and normal curves to be made in a true arc. Provide equipment used for the placement of thermoplastic pavement markings of two general types: mobile applicator and portable applicator.
- d. Equip the applicator with a pressurized or drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled

rates of flow. The bead dispenser must operate automatically to begin flow prior to the flow of binder to assure that the strip is fully reflectorized.

2.1.2.2.3 Portable Application Equipment

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines; and capable of applying thermoplastic pavement markings by the extrusion method. Equip the portable applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, capable of holding the molten thermoplastic at the temperature recommended by the manufacturer, and of extruding a line of 3 to 12 inches in width, and in thickness of not less than 0.120 inch nor more than 0.190 inch and of generally uniform cross section.

2.1.2.3 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the paint dispenser or thermoplastic dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.1.2.4 Preformed Tape Application Equipment

Provide and use mechanical application equipment for the placement of preformed marking tape which is a mobile pavement marking machine specifically designed for use in applying pressure-sensitive pavement marking tape of varying widths. Equip the applicator with rollers, or other suitable compaction device to provide initial adhesion of the material with the pavement surface. Use additional tools and devices as needed to properly seat the applied material as recommended by the manufacturer.

2.2 MATERIALS

Use waterborne paint thermoplastic high build acrylic for roads. Use non-reflectorized waterborne paint for automotive parking areas. The maximum allowable VOC content of pavement markings is 150 grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and automotive parking areas and SAE AMS-STD-595A for airfields. Provide materials conforming to the requirements specified herein.

2.2.1 Waterborne Paint

FS TT-P-1952, Type I or II .

2.2.2 Thermoplastic Compound

2.2.2.1 Composition Requirements

Thermoplastic compound must conform to AASHTO M 249. Formulate the binder component as an alkyd resin.

2.2.2.2 Primer

- a. Asphalt concrete primer: Provide thermosetting adhesive primer with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent for asphaltic concrete pavements. The solids content must not be less than 10 percent by weight at 70 degrees F and 60 percent relative humidity. A wet film thickness of 0.005 inch, plus or minus 0.001 inch, must dry to a tack-free condition in less than 5 minutes.
- b. Portland cement concrete primer: Provide an epoxy resin primer for Portland cement concrete pavements, of the type recommended by the manufacturer of the thermoplastic composition.

2.2.3 High Build Acrylic Coating (HBAC)

Formulate High Build Acrylic Coating (HBAC) to meet the requirements of Table II.

TABLE II - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
Resin System (ASTM D2621)	Waterborne 100 percent Acrylic
Percent Volume Solids (ASTM D2697)	58 percent
Volatile Organic Compound, max. (ASTM D3960)	1.25 lbs/gal
White (SAE AMS-STD-595A)	37925
Yellow (SAE AMS-STD-595A)	33538
Shore D Hardness (ASTM D2240)	45
1/8 inch Mandrel Bend at 5 mils Dry Film Thickness (DFT, one-week cure (ASTM D522/D522M, Method B)	No visual defects at bend (Conditions at ASTM D3924)
Adhesion to Concrete and Asphaltic Pavements (ASTM D4541)	140 psi or 100 percent cohesive failure in pavement
Accelerated Weathering, Yellow, 2500 Hours UV Exposure (ASTM G154: see note 1)	Max. color loss to 33655 (SAE AMS-STD-595A)
Water Absorption at 168 Hours Immersion Tap Water (ASTM D471)	9.0 percent max. weight increase (conditions at ASTM D3924)

TABLE II - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
Application at 65 mils Wet,One Coat, One-week Cure, (see note 2)	No visual cracking or curling (conditions at ASTM D3924)
No Pick-Up at 25 mils (ASTM D711)	Wet 10 minutes max.
Lead (ASTM D3335)	0.06 percent max.
Cadmium (ASTM D3335)	0.06 percent max.
Chromium (ASTM D3718)	0.00 percent
Notes:	
(1) Properly mix and apply yellow paint at 10 mils plus or minus 2 mils DFT over a suitably sized, clean aluminum substrate (ASTM D823), and cure for a minimum of 48 hours: prepare four individual yellow samples. Expose three samples to continuous Ultraviolet (UV) light for 2500 hours, without cycles condensation, in accordance to ASTM G154: use UVA-340 lamps in the testing apparatus. Following exposure, compare the three exposed samples to the "one" non-exposed sample using SAE AMS-STD-595A colors 33538 and 33655 as visual references: evaluate exposed samples for degree of visual color loss. Yellow paint is rated as passing if each exposed sample appears equivalent to the non-exposed sample, and in addition, displays color loss no greater than SAE AMS-STD-595A color 33655.	
(2) Using double-stick, foam mounting tape (or equal) with a nominal thickness of 65 mils, apply a rectangular mold with inner dimensions of 3 in by 10 in to a clean aluminum sample approximately sized at 6 in by 12 in by 1/8 in. Do not remove the tape's plastic backing. Mix and apply excess paint into mold. Remove excess paint, by squeegee or other appropriate draw down technique, to a uniform thickness equal to the tape's height. Perform paint application and draw down within a period of no more than 60 seconds. Approximately one to two minutes following the draw down, remove tape from sample and allow coating to cure for a minimum period of one week ASTM D3924. Using a micrometer or other appropriate device, measure cured coating thickness (less sample thickness) to confirm resulting coating application was at or above 38 mils DFT. Inspect coating for visual signs of cracking and curling. Following a one week cure, the coating is rated as passing if applied greater than 38 mils DFT and visually free of both cracking and curling.	

2.2.4 Preformed Tape

Provide adherent reflectorized strip preformed tape in accordance with [ASTM D4505](#) Retroreflectivity Level II, Class 1, 2 or 3, Skid Resistance Level B.

2.2.5 Reflective Media

2.2.5.1 Reflective Media for Roads

[FS TT-B-1325](#), Type I, Gradation A .

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning, or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a [12 inch by 12 inch](#) section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine [cleanliness, adhesion of remaining coating](#) and rate of cleaning. [Perform a demonstration removal of pavement marking in an area designated by the Contracting Officer. Approved demonstration area establishes the standard for the remainder of the work.](#)

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than [50 feet](#) long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer prior to proceeding with the work.

3.1.5 Level of Performance Demonstration

The Contracting Officer will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Contracting Officer.

3.2 EXTERIOR SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Remove rubber deposits, existing paint markings, residual curing compounds, and other coatings adhering to the pavement by water blasting or approved chemical removal method.

- a. For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.
- b. Do not use shot blasting on airfield pavements due to the potential of Foreign Object Damage (FOD) to aircraft. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.2.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.3 APPLICATION

Apply pavement markings to dry pavements only.

3.3.1 Paint

Apply paint with approved equipment at rate of coverage specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint

specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. If there is a deficiency in drying of the markings, painting operations must cease until the cause of the slow drying is determined and corrected.

3.3.1.1 Waterborne Paint

3.3.1.1.1 Roads

Apply paint at a rate of 105 plus or minus 5 square feet per gallon. Apply FS TT-B-1325 Type I (Gradation A) beads at a rate of 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.1.2 Epoxy Paint

Apply paint evenly to the pavement surface at a wet film thickness of 20 mils plus or minus 1 mil to cover 80 plus or minus 4 square feet per gallon. Apply glass spheres uniformly to the wet paint on road and street pavement at a rate of 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.1.3 High Build Acrylic Coating

Apply High Build Acrylic Coating (HBAC) at a rate of 50 square feet per gallon. Apply Type IV (Gradation A) beads at a minimum rate of 16 pounds of glass spheres per gallon.

3.3.2 Thermoplastic Compound

Place thermoplastic pavement markings, free from dirt or tint, upon dry pavement. The temperature must be a minimum of 40 degrees F and rising at the time of installation. Apply all centerline, skipline, edgeline, and other longitudinal type markings with a mobile applicator. Place all special markings, crosswalks, stop bars, legends, arrows, and similar patterns with a portable applicator, using the extrusion method.

3.3.2.1 Primer

After surface preparation has been completed, prime the asphalt or concrete pavement surface with spray equipment. Allow primer materials to "set-up" prior to applying the thermoplastic composition. Allow the asphalt concrete primer to dry to a tack-free condition, usually occurring in less than 10 minutes. Apply asphalt concrete primer to all asphalt concrete pavements at a wet film thickness of 0.005 inch, plus or minus 0.001 inch (265 to 400 square feet per gallon).

After the primer has "set-up", apply the thermoplastic at temperatures no lower than 375 degrees F nor higher than 425 degrees F at the point of deposition. Apply all extruded thermoplastic markings at the specified width and at a thickness of not less than 0.125 inch nor more than 0.190 inch. Apply all sprayed thermoplastic markings at the specified width and the thickness designated in the contract plans. If the plans do not specify a thickness, apply centerline markings at a wet thickness of 0.090 inch, plus or minus 0.005 inch, and edgeline markings at a wet thickness of 0.060 inch, plus or minus 0.005 inch.

3.3.2.2 Reflective Media

Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to **FS TT-B-1325** Type I (Gradation A) at the rate of **one pound per 20 square feet** such that the spheres are held by and imbedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. If there is a malfunction of either thermoplastic applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.3.3 Preformed Tape

The pavement surface and ambient air temperature must be a minimum of **60 degrees F** and rising. Place the preformed markings in accordance with the manufacturer's written instructions.

3.3.4 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and application operations. Dispose of debris at approved sites.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling and Testing

As soon as the paint and thermoplastic materials and reflective media are available for sampling, obtain by random selection from the sealed containers, four quart samples of each batch in the presence of the Contracting Officer. Two quarts will be for sampling and testing by the Contractor and two quarts will be for retention by the Government. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved.

At the discretion of the Contracting Officer, samples provided may be tested by the Government for verification.

3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. Provide test results substantiating conformance to the specified requirements with each certificate of compliance.

3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

-- End of Section --

SECTION 32 31 13.53

HIGH-SECURITY FENCES (CHAIN LINK AND ORNAMENTAL) AND GATES

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2023) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A478	(1997; R 2019) Standard Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R 2022) Standard Specification for Metallic-Coated Steel Marcellled Tension Wire for Use With Chain Link Fence
ASTM C94/C94M	(2023) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2023) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014; R 2023) Standard Specification for Fence Fittings
ASTM F668	(2017; R 2022) Standard Specification for Polyvinyl Chloride (PVC) and Other Polymer-Coated Steel Chain Link Fence Fabric
ASTM F900	(2011; R 2017) Standard Specification for Industrial and Commercial Swing Gates
ASTM F934	(2016; R 2022) Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials
ASTM F1043	(2018; R 2022) Standard Specification for

Strength and Protective Coatings on Steel
Industrial Fence Framework

ASTM F1184

(2023; E 2023) Standard Specification for
Industrial and Commercial Horizontal Slide
Gates

ASTM F1910

(1998; R 2018) Standard Specification for
Long Barbed Tape Obstacles

ASTM F1911

(2005; R 2019) Standard Practice for
Installation of Barbed Tape

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Installation Drawings; G

SD-03 Product Data

Fabric

Posts

Post Caps

Chain Link Braces

Rails

Tension Wire

Barbed Wire

Barbed Wire Supporting Arms

Barbed Tape

Latches

Hinges

Stops

Keepers

Rollers

Wire Ties

SD-07 Certificates

Chain Link Fence

Fabric

Barbed Wire

Gate Hardware and Accessories

Concrete

SD-10 Operation and Maintenance Data

Electro-Mechanical Locks

Operating and maintenance instructions

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials elevated off of the ground to protect against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 COMPONENTS

2.1.1 Chain Link Fence Fabric

2.1.1.1 General

Provide Class 2b polyvinyl chloride-coated steel fabric with 0.3 ounces of zinc coating per square foot in accordance with ASTM F668. Provide manufacturer's standard black in color for polyvinyl chloride coating for fabric and all other fence components complying with ASTM F934. Fabricate fence fabric of 9 gauge wire woven in 2 inch diamond mesh.

2.1.1.2 Approval Of Polyvinyl Chloride-Coated Fence Materials

Inspect polyvinyl chloride-coated fence materials for cracking, peeling, and conformance with the specifications prior to installation. Replace any fence materials rejected by the Contracting Officer with approved materials at no additional cost to the Government.

2.1.2 Posts

2.1.2.1 Metal Posts for Chain Link Fence

Provide posts with polyvinyl chloride coating, minimum thickness, 0.01 inch conforming to ASTM F1043; color of PVC coating to match that of fabric. Provide sizes as shown on the drawings. Use line posts and terminal (corner, gate, and pull) posts of the same designation throughout the fence. Provide gate post for the gate type specified subject to the limitation specified in ASTM F900 or ASTM F1184.

2.1.2.2 Accessories

- a. Provide accessories conforming to ASTM F626. Coat ferrous accessories with polyvinyl chloride-coated, minimum thickness of 0.01 inch. Match color coating of fittings to color coating of the fabric.
- b. Provide truss rods (with turnbuckles or other means of adjustment) for each terminal post.
- c. Provide barbed wire supporting arms of the 45 degree outward angle 3-strand arm type and of the design required for the post furnished. Secure arms by top railbolting.
- d. Furnish post caps in accordance with manufacturer's standard accessories .
- e. Provide 9 gauge tie wire for attaching fabric to rails, braces, and posts and match the material and coating of the fence fabric. Use tie wires for attaching fabric to tension wire on high security fences made from 16 gauge stainless steel. Provide double loop tie wires 6.5 inches in length. Provide miscellaneous hardware coatings which conform to ASTM A153/A153M unless modified.

2.1.3 Chain Link Braces and Rails

Provide rails and braces with polyvinyl chloride coating, minimum thickness, 0.01 inch conforming to ASTM F1043; color of PVC coating to match that of fabric.

2.1.4 Chain Link Gates

2.1.4.1 Gate Assembly

Provide gate assembly conforming to ASTM F900 and/or ASTM F1184 of the type and swing shown. Provide gate frames made of polyvinyl chloride-coated steel pipe (Group IA)(Group IC) a nominal pipe size (NPS) 1-1/2, conforming to ASTM F1043. Use gate fabric that matches the specified chain link fabric.

2.1.4.2 Gate Leaves

For gate leaves, more than 8 feet wide, provide either intermediate members and diagonal truss rods or tubular members as necessary to provide rigid construction, free from sag or twist. For gate leaves less than 8 feet wide, provide truss rods or intermediate braces. Provide intermediate braces on all gate frames with an electro-mechanical lock. Attach fabric to the gate frame by method standard with the manufacturer. Welding is not an acceptable method for attaching fabric to gate frames.

2.1.4.3 Gate Hardware and Accessories

Submit manufacturer's catalog data. Furnish and install [latches](#), [hinges](#), [stops](#), [keepers](#), [rollers](#), and other hardware items as required for the operation of the gate. All items are required to match the material characteristics of the fence system being installed. Provide hinge with stainless steel pin. Arrange latches for padlocking so that the padlock will be accessible from both sides of the gate. Provide stops for holding the gates in the open position. For high security applications, extend each end member of gate frames sufficiently above the top member to carry three strands of barbed wire in horizontal alignment with barbed wire strands on the fence. Coating for steel latches, stops, hinges, keepers, and accessories, must be PVC, minimum thickness of [0.01 inch](#).

2.1.5 [Electro-Mechanical Locks](#)

Provide electro-mechanical locking devices for sliding gates and personnel gates that are solenoid actuated such that the deadbolt retracts when the solenoid is energized and remains electrically retracted until the gate is closed. Provide continuous duty type solenoid, rated for 120V ac, 60Hz operation. Ensure the locking device is unlockable by key and keyed on both sides. Monitor status of the electro-mechanical lock by two limit switches (integral to the locking device) wired in series. Ensure one switch monitors the deadlock lever and the other monitors the locking tongue.

2.2 MATERIALS

2.2.1 Wire

2.2.1.1 [Wire Ties](#)

Submit samples as specified. Provide wire ties constructed of the same material and finish as the fencing fabric.

2.2.1.2 [Barbed Wire](#)

Provide barbed wire conforming to ASTM A121 zinc-coated, Type Z, Class 3, with 12.5 gauge wire with 14 gauge, round, 4-point barbs spaced no more than [5 inches](#) apart.

2.2.1.3 Tension Wire

Provide metallic coated steel marcelled tension wire (No. 7-gauge), complying with [ASTM A824](#).

2.2.2 [Barbed Tape](#)

Provide reinforced barbed tape, single coil, for fence toppings fabricated from 430 series stainless steel with a hardness range of Rockwell (30N) 37-45 conforming to the requirements of [ASTM A240/A240M](#). Provide stainless steel strip [0.025 inch thick by 1 inch](#) wide before fabrication. Provide barbs that are a minimum of [1.2 inch](#) in length, in groups of 4, spaced on [4 inch](#) centers. Use stainless steel core wire with a [0.098 inch](#) diameter and a minimum tensile strength of [140 psi](#) and conforming to [ASTM A478](#). The above requirements also apply to reinforced barbed tape, single coil, for ground application. Use [No. 16 AWG](#) stainless steel twistable wire ties for attaching the barbed tape to the barbed wire.

Ensure long barbed tape obstacles conform to [ASTM F1910](#).

2.2.3 Concrete

ASTM C94/C94M, using 3/4 inch maximum size aggregate, and having minimum compressive strength of 3000 psi at 28 days. Use grout consisting of one part portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix.

PART 3 EXECUTION

3.1 PREPARATION

Perform complete installation conforming to ASTM F567.

3.1.1 Line and Grade

Install fence to the lines and grades indicated. Clear the area on either side of the fence line to the extent indicated. Space line posts equidistant at intervals not exceeding 10 feet. Set terminal (corner, gate, and pull) posts whenever abrupt changes in vertical and horizontal alignment are encountered. Provide continuous fabric between terminal posts; however, ensure runs between terminal posts do not exceed 500 feet. Repair any damage to galvanized surfaces, including welding, with paint containing zinc dust in accordance with ASTM A780/A780M.

3.1.2 Excavation

Excavate holes to depths indicated. Clear all post holes of loose material and spread waste material where directed. Eliminate ground surface irregularities along the fence line to the extent necessary to maintain a 2 inch clearance between the bottom of the fabric and finish grade.

3.2 INSTALLATION

3.2.1 Installation Drawings

Submit complete Fence Installation Drawings for review and approval by the Contracting Officer prior to shipment. Submit drawing details that include, but are not limited to the following information: Fence Installation Drawings, Location of gate, corner, end, and pull posts, Gate Assembly, Turnstiles, and Gate Hardware and Accessories. Install fence system per approved drawings.

3.2.2 Security Fencing

Install new security fencing, remove existing security fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer.

3.2.3 Posts

3.2.3.1 Earth and Bedrock

- a. Set posts plumb and in alignment. Except where solid rock is encountered, set posts in concrete to the depth indicated on the drawings. Where solid rock is encountered with no overburden, set posts to a minimum depth of 18 inches in rock. Where solid rock is covered with an overburden of soil or loose rock, set posts to the minimum depth indicated on the drawing unless a penetration of 18

inches in solid rock is achieved before reaching the indicated depth, in which case terminate depth of penetration. Grout all portions of posts set in rock.

- b. Set portions of posts not set in rock in concrete from the rock to ground level. Set posts in holes not less than the diameter shown on the drawings. Make diameters of holes in solid rock at least 1 inch greater than the largest cross section of the post. Thoroughly consolidate concrete and grout around each post, free of voids and finished to form a dome. Allow concrete and grout to cure for 72 hours prior to attachment of any item to the posts. Group II line posts may be mechanically driven, for temporary fence construction only, if rock is not encountered. Set driven posts to a minimum depth of 3 feet and protect with drive caps when setting.
- c. Test fence post rigidity by applying a 50 pound force on the post, perpendicular to the fabric, at 5 feet above ground. Ensure post movement measured at the point where the force is applied is less than or equal to 3/4 inch from the relaxed position. Test every tenth post for rigidity. When a post fails this test, make further tests on the next four posts on either side of the failed post. Remove, replace, and retest all failed parts at the Contractor's expense.

3.2.4 Rails

Bolt bottom rail to double rail ends and securely fasten double rail ends to the posts. Peen bolts to prevent easy removal. Install bottom rail before chain link fabric.

3.2.5 Fabric

- a. Set fabric height as shown.
- b. Install chain link fabric on the side of the post indicated. Attach fabric to terminal posts with stretcher bars and tension bands. Space bands at approximately 15 inch intervals. Install fabric and pull taut to provide a smooth and uniform appearance free from sag, without permanently distorting the fabric diamond or reducing the fabric height. Fasten fabric to line posts at approximately 15 inch intervals and fastened to all rails and tension wires at approximately 12 inch intervals.
- c. Cut fabric by untwisting and removing pickets. Accomplish splicing by weaving a single picket into the ends of the rolls to be joined. Install the bottom of the fabric 1 plus or minus 1/2 inch above the ground.
- d. After the fabric installation is complete, exercise the fabric by applying a 50 pound push-pull force at the center of the fabric between posts; use a 30 pound pull at the center of the panel to ensure fabric deflection of not more than 2.5 inches when pulling fabric from the post side of the fence. Every second fence panel is required to meet this requirement. Resecure and retest all failed panels at the Contractor's expense.

3.2.6 Supporting Arms

Install barbed wire supporting arms and barbed wire as indicated on the drawings and as recommended by the manufacturer. Anchor supporting arms

to the posts in a manner to prevent easy removal with hand tools Pull barbed wire taut and attach to the arms with clips or other means that will prevent easy removal.

3.2.7 Barbed Tape Installation

Install stainless steel reinforced barbed tape per [ASTM F1911](#) and as detailed on the drawings. Stretch out barbed tape to its manufacturer's recommended length, set on top of the barbed wire and "V" shaped support arms, then secure it to the barbed wire. Secure the barbed tape to the barbed wire at the two points and at every spiral turn of both coils as shown on the drawings. Install stainless steel reinforced barbed tape for ground applications in accordance with manufacturer's recommendations.

3.2.8 Gate Installation

- a. Install gates at the locations shown. Mount gates to swing as indicated. Install latches, stops, and keepers as required. Install Slide gates as recommended by the manufacturer.
- b. Attach padlocks to gates or gate posts with chains. Weld or otherwise secure hinge pins, and hardware assembly to prevent removal.
- c. Submit 6 copies of [operating and maintenance instructions](#). Outline the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Include in the maintenance instructions routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. Also include the general gate layout, equipment layout and simplified wiring and control diagrams of the system as installed.

3.2.9 Grounding

- c. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within [50 feet](#) of the fence, and where the fence alignment changes more than 15 degrees. Ensure grounding locations are located no more than [650 feet](#) apart. Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by powerlines of 600 volts or more at or near the point of crossing and at distances not exceeding [150 feet](#) on each side of crossing.
- d. Provide ground conductor consisting of [No. 8 AWG](#) solid copper wire. Use grounding electrodes that measures [3/4 inch](#) by [10 foot](#) long and are a copper-clad steel rod. Drive electrodes into the earth so that the top of the electrode is at least [6 inches](#) below the grade. Where driving is impracticable, bury electrodes a minimum of [12 inches](#) deep and radially from the fence. Install the top of the electrode to be less than [2 feet](#) or more than [8 feet](#) from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Measure total resistance of the fence to ground and ensure it is not greater than 25 ohms.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Cleanup

Remove waste fencing materials and other debris from the work site each workday.

-- End of Section --

SECTION 32 92 19

SEEDING

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C602 (2020) Agricultural Liming Materials

ASTM D4972 (2018) Standard Test Methods for pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

DOA SSIR 42 (1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 92 23 SODDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood Cellulose Fiber Mulch

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil Composition Tests (reports and recommendations).

SD-07 Certificates

State Certification and Approval for Seed

SD-08 Manufacturer's Instructions

Erosion Control Materials

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Seed Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer Gypsum Sulfur Iron and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer gypsum sulphur iron and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Seed, Fertilizer Gypsum Sulfur Iron and Lime Storage

Store in cool, dry locations away from contaminants.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Seed

Apply seed within twenty four hours after seed bed preparation.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Classification

Provide State-certified seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. Label in conformance with **AMS Seed Act** and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2 Planting Dates

Planting Season	Planting Dates
Permanent Seeding	Early Spring - Summer
Temporary Seeding	Per GSWCC Manual

2.1.3 Seed Purity

Botanical Name	Common Name	Minimum Percent Pure Seed		Maximum Percent Weed Seed
Cynodon dactylon	Bermuda grass	97		3

2.1.4 Seed Mixture by Weight see plans and GSWCC Manual

Proportion seed mixtures by weight. Temporary seeding must later be replaced by permanent plantings for a permanent stand of grass. The same requirements of turf establishment for permanent apply for temporary seeding.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional

topsoil must be furnished by the Contractor .

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the [topsoil composition tests](#) of the Organic Carbon, 6A, Chemical Analysis Method described in [DOA SSIR 42](#). Maximum particle size, [3/4 inch](#), with maximum 3 percent retained on [1/4 inch](#) screen. The pH must be tested in accordance with [ASTM D4972](#). Topsoil must be free of sticks, stones, roots, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	25-50 percent
Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in [ASTM C602](#) of not less than [90](#) percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Sand

Clean and free of materials harmful to plants.

2.3.6 Perlite

Horticultural grade.

2.3.7 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.7.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.7.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.8 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.9 Calcined Clay

Calcined clay must be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent must pass a No. 8 sieve; a minimum 99 percent must be retained on a No. 60 sieve; and material passing a No. 100 sieve must not exceed 2 percent. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

- 6 percent available nitrogen
- 12 percent available phosphorus
- 12 percent available potassium

2.4.2 Hydroseeding Fertilizer

Controlled release fertilizer, to use with hydroseeding and composed of pills coated with plastic resin to provide a continuous release of nutrients for at least 6 months and containing the following minimum percentages, by weight, of plant food nutrients.

- 6 percent available nitrogen
- 12 percent available phosphorus
- 6 percent available potassium

2.5 MULCH

Mulch must be free from noxious weeds, mold, and other deleterious materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw must contain no fertile seed.

2.5.2 Hay

Air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Hay must be sterile, containing no fertile seed.

2.5.3 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent post-consumer content) or wood-based (100 percent total recovered content) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 5.5 to 8.2 . Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water must be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

2.7 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.7.1 Erosion Control Blanket

70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 18 months.

2.7.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings $\frac{3}{4}$ to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.7.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.7.4 Hydrophilic Colloids

Hydrophilic colloids must be physiologically harmless to plant and animal life without phytotoxic agents. Colloids must be naturally occurring, silicate powder based, and must form a water insoluble membrane after curing. Colloids must resist mold growth.

2.7.5 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation prior to planting (including soil conditioners as

required), fertilizing, seeding, and surface topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.1.1 Topsoil

Provide 4 inches of off-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer pH adjusters soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site. For bidding purposes only apply at rates for the following:

Lime 3000 pounds per acre

3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy frozen snow covered or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method must be broadcast and drop seeding drill seeding hydroseeding.

3.2.2.1 Broadcast and Drop Seeding

Seed must be uniformly broadcast at the rate of manufacture's recommendation pounds per 1000 square feet. Use broadcast or drop seeders. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing. Cover seed uniformly to a maximum depth of 1/4 inch in clay soils and 1/2 inch in sandy soils by means of spike-tooth harrow, cultipacker, raking or other approved devices.

3.2.2.2 Drill Seeding

Seed must be drilled at the rate of manufacture's recommendation pounds per 1000 square feet. Use grass seed drills. Drill seed uniformly to average depth of 1/2 inch.

3.2.2.3 Hydroseeding

First, mix water and fiber. Wood cellulose fiber, paper fiber, or recycled paper must be applied as part of the hydroseeding operation.

Fiber must be added at 1,000 pounds, dry weight, per acre. Then add and mix seed and fertilizer to produce a homogeneous slurry. Seed must be mixed to ensure broadcasting at the rate of manufacture's recommendation pounds per 1000 square feet. When hydraulically sprayed on the ground, material must form a blotter like cover impregnated uniformly with grass seed. Spread with one application with no second application of mulch.

3.2.3 Mulching

3.2.3.1 Hay or Straw Mulch

Hay or straw mulch must be spread uniformly at the rate of 2 tons per acre. Mulch must be spread by hand, blower-type mulch spreader, or other approved method. Mulching must be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch must not be bunched or clumped. Sunlight must not be completely excluded from penetrating to the ground surface. All areas installed with seed must be mulched on the same day as the seeding. Mulch must be anchored immediately following spreading.

3.2.4 Rolling

Immediately after seeding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width.

3.2.5 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.6 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 2 inches without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 92 23

SODDING

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C602 (2020) Agricultural Liming Materials

ASTM D4972 (2018) Standard Test Methods for pH of Soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS (1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42 (1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

100 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, , , Section 32 92 19 SEEDING, , Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-07 Certificates

Sod farm certification for sods. Indicate type of sod in accordance with TPI GSS.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Sod Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer Gypsum Sulfur Iron and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer gypsum sulphur iron and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Sod Storage

Lightly sprinkle with water, cover with moist burlap, straw, or other approved covering; and protect from exposure to wind and direct sunlight until planted. Provide covering that will allow air to circulate so that internal heat will not develop. Do not store sod longer than 24 hours. Do not store directly on concrete or bituminous surfaces.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Sod

Place sod a maximum of thirty six hours after initial harvesting, in

accordance with TPI GSS as modified herein.

PART 2 PRODUCTS

2.1 SODS

2.1.1 Classification

Nursery grown, certified as classified in the TPI GSS. Machine cut sod at a uniform thickness of 3/4 inch within a tolerance of 1/4 inch, excluding top growth and thatch. Each individual sod piece shall be strong enough to support its own weight when lifted by the ends. Broken pads, irregularly shaped pieces, and torn or uneven ends will be rejected. Wood pegs and wire staples for anchorage shall be as recommended by sod supplier.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Planting Dates

Lay sod per manufacture's recommendation

2.1.4 Composition

2.1.4.1 Proportion

Proportion grass species as follows.

Botanical Name	Common Name	Percent
Cynodon dactylon	Common Bermuda grass	100

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil shall be furnished by the Contractor .

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH shall be tested in

accordance with [ASTM D4972](#). Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	25-50 percent
Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in [ASTM C602](#) of not less than 90 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Sand

Clean and free of materials harmful to plants.

2.3.6 Perlite

Horticultural grade.

2.3.7 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.7.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.7.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.8 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.9 Calcined Clay

Calcined clay shall be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent shall pass a No. 8 sieve; a minimum 99 percent shall be retained on a No. 60 sieve; and a maximum 2 percent shall pass a No. 100 sieve. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

- 6 percent available nitrogen
- 12 percent available phosphorus
- 12 percent available potassium

2.5 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation containing no element toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Extent Of Work

Provide soil preparation (including soil conditioners), fertilizing, and sodding of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.2 Soil Preparation

Provide 4 inches of off-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer pH adjusters soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas

from damage by vehicular or pedestrian traffic.

3.1.2.1 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site. For bidding purposes only apply at rates for the following:

Lime 3000 pounds per 1000 square feet.3.2 SODDING

3.2.1 Finished Grade and Topsoil

Prior to the commencement of the sodding operation, the Contractor shall verify that finished grades are as indicated on drawings; the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 31 00 00 EARTHWORK.

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove from the surface debris and stones over a minimum 5/8 inch in any dimension.

3.2.2 Placing

Place sod a maximum of 36 hours after initial harvesting, in accordance with TPI GSS as modified herein.

3.2.3 Sodding Slopes and Ditches

For slopes 2:1 and greater, lay sod with long edge perpendicular to the contour. For V-ditches and flat bottomed ditches, lay sod with long edge perpendicular to flow of water. Anchor each piece of sod with wood pegs or wire staples maximum 2 feet on center. On slope areas, start sodding at bottom of the slope.

3.2.4 Finishing

After completing sodding, blend edges of sodded area smoothly into surrounding area. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed and holes and missing corners shall be patched with sod.

3.2.5 Rolling

Immediately after sodding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width.

3.2.6 Watering

Start watering areas sodded as required by daily temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to minimum depth of 6 inches. Run-off, puddling, and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be driven over turf areas. Watering of other adjacent areas or plant material shall be prevented.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 93 00

EXTERIOR PLANTS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICANHORT (AH)

ANSI/ANLA Z60.1 (2004) American Standard for Nursery Stock

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M (2023) Standard Specification for
Stainless Steel Wire

ASTM C602 (2020) Agricultural Liming Materials

ASTM D4972 (2018) Standard Test Methods for pH of
Soils

ASTM D5268 (2019) Topsoil Used for Landscaping
Purposes

ASTM D6155 (2019) Nontraditional Coarse Aggregate for
Bituminous Paving Mixtures

L.H. BAILEY HORTORIUM (LHBH)

LHBH (1976) Hortus Third

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA A300P1 (2017) ANSI A300 Part1: Tree Care
Operations - Trees, Shrubs and Other Woody
Plant Maintenance Standard Practices -
Pruning

TCIA Z133 (2017) American National Standard for
Arboricultural Operations - Pruning,
Repairing, Maintaining, and Removing
Trees, and Cutting Brush - Safety
Requirements

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42 (1996) Soil Survey Investigation Report
No. 42, Soil Survey Laboratory Methods
Manual, Version 3.0

1.2 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 92 19 SEEDING, Section 32 92 23 SODDING, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

State Landscape Contractor's License

Time Restrictions and Planting Conditions

Indicate anticipated dates and locations for each type of planting.

SD-03 Product Data

Composted Derivatives

Organic Mulch Materials

Gypsum

Mulch; G

Ground Stakes

Fertilizer

Weed Control Fabric; G

Root Control Barrier; G

Staking Material

Metal Anchors

Antidesiccants

Erosion Control Materials

SD-04 Samples

Mulch; G

SD-06 Test Reports

Topsoil Composition Tests; ; ;

Percolation Test; ;

SD-07 Certificates

Nursery Certifications

SD-10 Operation and Maintenance Data

Plastic Identification

When not labeled, identify types in Operation and Maintenance Manual.

1.4 QUALITY ASSURANCE

1.4.1 Topsoil Composition Tests

Commercial test from an independent testing laboratory including basic soil groups (moisture and saturation percentages, Nitrogen-Phosphorus-Potassium (N-P-K) ratio, pH (ASTM D4972), soil salinity), secondary nutrient groups (calcium, magnesium, sodium, Sodium Absorption Ratio (SAR)), micronutrients (zinc, manganese, iron, copper), toxic soil elements (boron, chloride, sulfate), cation exchange and base saturation percentages, and soil amendment and fertilizer recommendations with quantities for plant material being transplanted. Soil required for each test must include a maximum depth of 18 inches of approximately one quart volume for each test. Areas sampled should not be larger than one acre and should contain at least 6-8 cores for each sample area and be thoroughly mixed. Problem areas should be sampled separately and compared with samples taken from adjacent non-problem areas. The location of the sample areas should be noted and marked on a parcel or planting map for future reference.

1.4.2 Nursery Certifications

- a. Indicate on nursery letterhead the name of plants in accordance with the LHBH, including botanical common names, quality, and size.
- b. Inspection certificate.
- c. Mycorrhizal fungi inoculum for plant material treated

1.4.3 State Landscape Contractor's License

Construction company must hold a landscape contractors license in the state where the work is performed and have a minimum of five years landscape construction experience. Submit copy of license and three references for similar work completed in the last five years.

1.4.4 Percolation Test

Immediately following rough grading operation, identify a typical location for one of the largest trees and or shrubs and excavate a pit per the

project details. Fill the pit with water to a depth of 12 inches. The length of time required for the water to percolate into the soil, leaving the pit empty, must be measured by the project Landscape Architect and verified by the Contracting Officer. Within six hours of the time the water has drained from the pit, the Contractor, with the Contracting Officer and project Landscape Architect present, must again fill the pit with water to a depth of 12 inches. If the water does not completely percolate into the soil within 9 hours, a determination must be made whether a drainage system or a soil penetrant will be required for each tree and or shrub being transplanted.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Branched Plant Delivery

Deliver with branches tied and exposed branches covered with material which allows air circulation. Prevent damage to branches, trunks, root systems, and root balls and desiccation of leaves.

1.5.1.2 Soil Amendment Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum, sulfur, iron, and lime may be furnished in bulk with a certificate indicating the above information. Store in dry locations away from contaminants.

1.5.1.3 Plant Labels

Deliver plants with durable waterproof labels in weather-resistant ink. Provide labels stating the correct botanical and common plant name and variety as applicable and size as specified in the list of required plants. Attach to plants, bundles, and containers of plants. Groups of plants may be labeled by tagging one plant. Labels must be legible for a minimum of 60 days after delivery to the planting site.

1.5.2 Storage

1.5.2.1 Plant Storage and Protection

Store and protect plants not planted on the day of arrival at the site as follows:

- a. Shade and protect plants in outside storage areas from the wind and direct sunlight until planted.
- b. Heel-in bare root plants.
- c. Protect balled and burlapped plants from freezing or drying out by covering the balls or roots with moist burlap, sawdust, wood chips, shredded bark, peat moss, or other approved material. Provide covering which allows air circulation.
- d. Keep plants in a moist condition until planted by watering with a fine mist spray.

- e. Do not store plant material directly on concrete or bituminous surfaces.

1.5.2.2 Fertilizer, Gypsum, pH Adjusters and Mulch Storage

Store in dry locations away from contaminants.

1.5.2.3 Topsoil

Prior to stockpiling topsoil, eradicate on site undesirable growing vegetation. Clear and grub existing vegetation three to four weeks prior to stockpiling existing topsoil.

1.5.2.4 Root Control Barrier and Weed Control Fabric

Store materials on site in enclosures or under protective covering in dry location. Store under cover out of direct sunlight. Do not store materials directly on ground.

1.5.3 Handling

Do not drop or dump plants from vehicles. Avoid damaging plants being moved from nursery or storage area to planting site. Handle balled and burlapped balled and potted container plants carefully to avoid damaging or breaking the earth ball or root structure. Do not handle plants by the trunk or stem. Remove damaged plants from the site.

1.5.4 TIME LIMITATION

Except for container-grown plant material, the time limitation from digging to installing plant material must be a maximum of 90 days. The time limitation between installing the plant material and placing the mulch must be a maximum of 24 hours.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Planting Dates

Per nursery recommendation 1.6.2 Restrictions

Do not plant when ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit

1.7 GUARANTEE

All plants must be guaranteed for one year beginning on the date of inspection by the Contracting Officer to commence the plant establishment period, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by the Government or by weather conditions unusual for the warranty period.

Guarantee plants installed during fall planting season until the following August 1 ; guarantee plants installed during spring planting season until the following October 1 . Replace palms which are not alive at the end of a one-year period.

Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season. At end of warranty period, replace planting materials that die or have 25 percent or more of their

branches that die during the construction operations or the guarantee period.

1.8 PLASTIC IDENTIFICATION

Provide product data indicating polymeric information in Operation and Maintenance Manual.

Type 1: Polyethylene Terephthalate (PET, PETE).

Type 2: High Density Polyethylene (HDPE).

Type 3: Vinyl (Polyvinyl Chloride or PVC).

Type 4: Low Density Polyethylene (LDPE).

Type 5: Polypropylene (PP).

Type 6: Polystyrene (PS).

Type 7: Other. Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.

PART 2 PRODUCTS

2.1 PLANTS

2.1.1 Regulations and Varieties

Furnish nursery stock in accordance with ANSI/ANLA Z60.1, except as otherwise specified or indicated. Each plant or group of planting must have a "key" number indicated on the nursery certifications of the plant schedule. Furnish plants, including turf grass, grown under climatic conditions similar to those in the locality of the project. . Plants of the same specified size must be of uniform size and character of growth. All plants must comply with all Federal and State Laws requiring inspection for plant diseases and infestation.

2.1.2 Shape and Condition

Well-branched, well-formed, sound, vigorous, healthy planting stock free from disease, sunscald, windburn, abrasion, and harmful insects or insect eggs and having a healthy, normal, and undamaged root system.

2.1.2.1 Deciduous Trees and Shrubs

Symmetrically developed and of uniform habit of growth, with straight boles or stems, and free from objectionable disfigurements.

2.1.2.2 Evergreen Trees and Shrubs

Well developed symmetrical tops with typical spread of branches for each particular species or variety.

2.1.2.3 Ground Covers and Vines

Number and length of runners and clump sizes indicated, and of the proper

age for the grade of plants indicated, furnished in removable containers, integral containers, or formed homogeneous soil section.

2.1.3 Plant Size

Minimum sizes measured after pruning and with branches in normal position, must conform to measurements indicated, based on the average width or height of the plant for the species as specified in ANSI/ANLA Z60.1. Plants larger in size than specified may be provided with approval of the Contracting Officer . When larger plants are provided, increase the ball of earth or spread of roots in accordance with ANSI/ANLA Z60.1.

2.1.4 Root Ball Size

All box-grown, field potted, field boxed, collected, plantation grown, bare root, balled and burlapped, container grown, processed-balled, and in-ground fabric bag-grown root balls must conform to ANSI/ANLA Z60.1. All wrappings and ties must be biodegradable. Root growth in container grown plants must be sufficient to hold earth intact when removed from containers. Root bound plants will not be accepted.

Mycorrhizal fungi inoculum Before shipment, root systems must contain mycorrhizal fungi inoculum.

2.1.5 Growth of Trunk and Crown

2.1.5.1 Deciduous Trees

A height to caliper relationship must be provided in accordance with ANSI/ANLA Z60.1. Height of branching must bear a relationship to the size and species of tree specified and with the crown in good balance with the trunk. The trees must not be "poled" or the leader removed.

- a. Single stem: The trunk must be reasonably straight and symmetrical with crown and have a persistent main leader.
- b. Multi-stem: All countable stems, in aggregate, must average the size specified. To be considered a stem, there must be no division of the trunk which branches more than 6 inches from ground level.

2.1.5.2 Palms

Palms must have the specified height as measured from the base of the trunk to the base of the fronds or foliage in accordance with ANSI/ANLA Z60.1. The palm must have straight trunk and healthy fronds or foliage as typical for the variety grown in the region of the project. Palms trimmed or pruned for delivery must retain a minimum of 6 inches of foliage at the crown as a means of determining plant health.

2.1.5.3 Deciduous Shrubs

Deciduous shrubs must have the height and number of primary stems recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped, with sufficient well-spaced side branches, and recognized by the trade as typical for the species grown in the region of the project.

2.1.5.4 Coniferous Evergreen Plant Material

Coniferous Evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. The coniferous evergreen trees must not be "poled" or the leader removed. Acceptable plant material must be

exceptionally heavy, well shaped and trimmed to form a symmetrical and tightly knit plant. The form of growth desired must be as indicated.

2.1.5.5 Broadleaf Evergreen Plant Material

Broadleaf evergreen plant material must have the height-to-spread ratio recommended by [ANSI/ANLA Z60.1](#). Acceptable plant material must be well shaped and recognized by the trade as typical for the variety grown in the region of the project.

2.1.5.6 Ground Cover and Vine Plant Material

Ground cover and vine plant material must have the minimum number of runners and length of runner recommended by [ANSI/ANLA Z60.1](#). Plant material must have heavy, well developed and balanced crown with vigorous, well developed root system and must be furnished in containers.

2.2 TOPSOIL

2.2.1 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.2 Composition

Evaluate soil for use as topsoil in accordance with [ASTM D5268](#). From 5 to 10 percent organic matter as determined by the [topsoil composition tests](#) of the Organic Carbon, 6A, Chemical Analysis Method described in [DOA SSIR 42](#). Maximum particle size, [3/4 inch](#), with maximum 3 percent retained on [1/4 inch](#) screen. The pH must be tested in accordance with [ASTM D4972](#). Topsoil must be free of sticks, stones, roots, plants, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	25-50 percent
Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Provide singly or in combination as required to meet specified requirements for topsoil. Soil conditioners must be nontoxic to plants.

2.3.1 Lime

Commercial grade burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in [ASTM C602](#) of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Sand

Clean and free of materials harmful to plants.

2.3.6 Perlite

Horticultural grade.

2.3.7 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, invasive species, including seeds, and soil stabilized with nitrogen and having the following properties:

2.3.7.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.7.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.8 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.4 PLANTING SOIL MIXTURES

100 percent topsoil as specified herein.

2.5 FERTILIZER

2.5.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

6 percent available nitrogen
12 percent available phosphorus
12 percent available potassium
percent sulfur

2.5.2 Fertilizer Tablets

Organic, plant tablets composed of tightly compressed fertilizer chips forming a tablet that is insoluble in water, is designed to provide a continuous release of nutrients for at least 24 months and contains the following minimum percentages, by weight, of plant food nutrients:

- 20 percent available nitrogen
- 20 percent available phosphorus
- 5 percent available potassium

2.6 WEED CONTROL FABRIC

2.6.1 Roll Type Polypropylene or Polyester Mats

Fabric must be woven, needle punched or non-woven and treated for protection against deterioration due to ultraviolet radiation. Fabric must be minimum 99 percent opaque to prevent photosynthesis and seed germination from occurring, yet allowing air, water and nutrients to pass thru to the roots. Minimum weight must be 5 ounces per square yard with a minimum thickness of 20 mils with a 20 year (minimum) guarantee.

2.7 MULCH

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.7.1 Inert Mulch Materials

Provide riverbank stone, complying with ASTM D6155, ranging in size from 1/4 inch_2 inches____).

2.7.2 Organic Mulch Materials

Provide pine straw mulch, or from site when available. Wood cellulose fiber must be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch must contain 100 percent post-consumer recycled content. Wood-based hydraulic mulch must contain 100 percent total recovered materials content.

2.8 STAKING AND GUYING MATERIAL

2.8.1 Staking Material

2.8.1.1 Tree Support Stakes

Rough sawn hard wood free of knots, rot, cross grain, bark, long slivers, or other defects that impair strength. Stakes must be minimum 2 inches square or 2-1/2 inch diameter by 8 feet long, pointed at one end..

2.8.1.2 Ground Stakes

Rough sawn hard wood or plastic, 2 inches square are by 3 feet long, pointed at one end.

2.8.2 Guying Material

2.8.2.1 Guying Wire

12 gauge annealed galvanized steel, [ASTM A580/A580M](#).

2.8.2.2 Guying Cable

Minimum five-strand, [3/16 inch](#) diameter galvanized steel cable .

2.8.3 Hose Chafing Guards

New or used 2 ply [3/4 inch](#) diameter reinforced rubber or plastic hose, black or dark green, all of same color.

2.8.4 Flags

White surveyor's plastic tape, , [12 inches](#) long, fastened to guying wires or cables.

2.8.5 Turnbuckles

Galvanized or cadmium-plated steel with minimum [3 inch](#) long openings fitted with screw eyes. Eye bolts must be galvanized or cadmium-plated steel with [one inch](#) diameter eyes and screw length [1-1/2 inches](#), minimum.

2.8.6 Deadmen

[4 by 8 inch](#) rectangular or [8 inch](#) diameter by [36 inch](#) long, pine wood material.

2.8.7 Metal Anchors

2.8.7.1 Driven Anchors

Malleable iron, arrow shaped, galvanized, sized as follows:

Tree Caliper	Anchor Size
2 inches and under	3 inches
3 to 6 inches	4 inches
6 to 8 inches	6 inches
8 to 10 inches	8 inches
10 to 12 inches	10 inches

2.8.7.2 Screw Anchors

Steel, screw type with welded-on [3 inch](#) round helical steel plate, minimum [3/8 inch](#) diameter, [15 inches](#) long.

2.9 ANTIDESICCANTS

Sprayable, water insoluble vinyl-vinledine complex which produce a moisture retarding barrier not removable by rain or snow. Film must form at temperatures commonly encountered out of doors during planting season and have a moisture vapor transmission rate (MVT) of the resultant film of maximum 10 grams per 24 hours at 70 percent humidity.

2.10 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.10.1 Erosion Control Blanket

70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 18 months.

2.10.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings $\frac{3}{4}$ to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.10.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.10.4 Hydrophilic Colloids

Hydrophilic colloids must be physiologically harmless to plant and animal life without phytotoxic agents. Colloids must be naturally occurring, silicate powder based, and must form a water insoluble membrane after curing. Colloids must resist mold growth.

2.10.5 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

2.11 ROOT CONTROL BARRIER

Flexible and permeable geotextile fabric with permanently attached time-released nodules. Color to be black . Pre-formed, round, tapered cylinder barrier with integral vertical root deflecting ribs constructed of ultraviolet resistant polypropylene material. Color to be black .

2.12 WATER

Source of water to be approved by Contracting Officer and suitable quality for irrigation and must not contain elements toxic to plant life.

2.13 MYCORRHIZAL FUNGI INOCULUM

Mycorrhizal fungi inoculum must be composed of multiple-fungus inoculum as recommended by the manufacturer for the plant material specified.

2.14 SOURCE QUALITY CONTROL

The Contracting Officer will inspect plant materials at the project site and approve them. Tag plant materials for size and quality.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide soil preparation, including soil conditioners prior to planting. Provide tree, shrub, groundcover, seed, and sod planting, post-planting fertilizer, staking, guying, weed control fabric, erosion control material, root control barrier installation, and mulch topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.2 PREPARATION

3.2.1 Layout

Stake out approved plant material locations and planter bed outlines on the project site before digging plant pits or beds. The Contracting Officer reserves the right to adjust plant material locations to meet field conditions. Do not plant closer than 36 inches to a building wall, pavement edge, fence or wall edge and other similar structures.

3.2.2 Soil Preparation

3.2.2.1 pH Adjuster Application Rates

Apply pH adjuster at rates as determined by laboratory soil analysis of the soils at the job site. For bidding purposes only apply at rates for the following:

Lime 50 pounds per 1000 square feet

3.2.2.2 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site. For bidding purposes only apply at rates for the following:

3.2.3 Root Control Barrier

Install geotextile fabric in the soil in a vertical horizontal and surrounding application. Use appropriate holding device to assure fabric position. For vertical or horizontal application, a minimum 2 inch soil cover is required over the top surface edge. A minimum 18 inch extension of fabric beyond the structure area to be protected is required to prevent root growth from growing around fabric edges. Install cylindrical linear polypropylene barrier a minimum 1/2 one inch above finish grade to prevent root growth over the barrier. Backfill the outside of the barrier with 3/4 to one gravel a minimum width of 2 inches. For linear barrier application use appropriate device to connect two pieces.

3.3 PLANT BED PREPARATION

Verify location of underground utilities prior to excavation. Protect

existing adjacent turf before excavations are made. Where planting beds occur in existing turf areas, remove turf to a depth that will ensure removal of entire root system. Measure depth of plant pits from finished grade. Depth of plant pit excavation must be as indicated and provide proper relation between top of root ball and finished grade. Install plant material as specified in paragraph PLANT INSTALLATION. Do not install trees within 10 feet of any utility lines or building walls.

3.4 PLANT INSTALLATION

3.4.1 Individual Plant Pit Excavation

Excavate pits at least twice as large in diameter as the size of ball or container to depth shown.

3.4.2 Plant Beds with Multiple Plants

Excavate plant beds continuously throughout entire bed as outlined to depth shown.

3.4.3 Handling and Setting

Move plant materials only by supporting the root ball container. Set plants on hand compacted layer of prepared backfill soil mixture 6 inches thick and hold plumb in the center of the pit until soil has been tamped firmly around root ball. Set plant materials, in relation to surrounding finish grade, one to 2 to 3 inches above depth at which they were grown in the nursery, collecting field or container. Replace plant material whose root balls are cracked or damaged either before or during the planting process.

Plant material must be set in plant beds according to the drawings. Backfill soil mixture must be placed on previously scarified subsoil to completely surround the root balls, and must be brought to a smooth and even surface, blending to existing areas.

3.4.3.1 Balled and Burlapped Stock

Backfill with topsoil to approximately half the depth of ball and then tamp and water. Carefully remove or fold back excess burlap and tying materials from the top a minimum 1/3 depth from the top of the rootball. Tamp and complete backfill, place mulch topdressing, and water. Remove wires and non-biodegradable materials from plant pit prior to backfill operations.

3.4.3.2 Bare-Root Stock

Plant so roots are arranged in a natural position. Place roots in water a minimum of 30 minutes prior to planting. Carefully work topsoil among roots. Tamp remainder of backfill, place mulch topdressing and water.

3.4.3.3 Container Grown Stock

Remove from container and prevent damage to plant or root system.

3.4.4 Earth Mounded Watering Basin for Individual Plant Pits

Form with topsoil around each plant by replacing a mound of topsoil around the edge of each plant pit. Watering basins must be 6 inches deep for

trees and 4 inches deep for shrubs. Eliminate basins around plants in plant beds containing multiple plants.

3.4.5 Weed Control Fabric Installation

Remove grass and weed vegetation, including roots, from within the area enclosed by edging. Completely cover areas enclosed by edging with specified weed control fabric prior to placing mulch layer. Overlap cut edges 6 inches.

3.4.6 Erosion Control Material

Install in accordance with manufacturer's instructions.

3.4.7 Placement of Mulch Topdressing

Place specified mulch topdressing on top of weed control fabric covering total area enclosed by edging. Place mulch topdressing to a depth of 3 inches.

3.4.8 Mulch Topdressing

Provide mulch topdressing over entire planter bed surfaces and individual plant surfaces including earth mound watering basin around plants to a depth of 3 inches after completion of plant installation and before watering. Keep mulch out of the crowns of shrubs. Place mulch a minimum 2 to 3 inches away from trunk of shrub or tree. Place on top of any weed control fabric.

3.4.9 Fertilization

3.4.9.1 Fertilizer Tablets

Place fertilizer planting tablets evenly spaced around the plant pits to the manufacturer's recommended depth.

3.4.9.2 Granular Fertilizer

Apply granular fertilizer as a top coat prior to placing mulch layer and water thoroughly.

3.4.10 Watering

Start watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 12 inches without run off.

3.4.11 Staking and Guying

3.4.11.1 Staking

Stake plants with the number of stakes indicated complete with double strand of 12 gage guy wire as detailed. Attach guy wire half the tree height but not more than 5 feet high. Drive stakes to a depth of 2-1/2 to 3 feet into the ground outside the plant pit. Do not injure the root ball. Use hose chaffer guards where guy wire comes in contact with tree trunk.

3.4.11.2 Guying

Guy plants as indicated. Attach two strands of guying wire guying cable around the tree trunk at an angle of 45 degrees at approximately 1/2 of the trunk height . Protect tree trunks with chafing guards where guying wire contacts the tree trunk. Anchor guys to deadmen wood blocks . Fasten flags to each guying wire approximately 2/3 of the distance up from ground level. Provide turnbuckles as indicated.

3.4.11.3 Chafing Guards

Use hose chafing guards, as specified where guy wire will contact the plant.

3.4.12 Pruning

Prune in accordance with safety requirement of TCIA Z133.

3.4.12.1 Trees and Shrubs

Remove dead and broken branches. Prune to correct structural defects only. Retain typical growth shape of individual plants with as much height and spread as practical. Do not cut central leader on trees. Make cuts with sharp instruments. Do not flush cut with trunk or adjacent branches. Collars must remain in place. Pruning must be accomplished by trained and experienced personnel and must be accordance with TCIA A300P1.

3.4.12.2 Wound Dressing

Do not apply tree wound dressing to cuts.

3.5 RESTORATION AND CLEAN UP

3.5.1 Restoration

Turf areas, pavements and facilities that have been damaged from the planting operation must be restored to original condition at the Contractor's expense.

3.5.2 Clean Up

Excess and waste material must be removed from the installed area and must be disposed offsite at an approved landfill, recycling center, or composting center. Separate and recycle or reuse the following landscape waste materials: nylon straps, wire, ball wrap, burlap, wood stakes, . Adjacent paved areas must be cleared.

-- End of Section --

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C104/A21.4	(2022) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2018) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2021) Ductile-Iron and Gray-Iron Fittings
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C153/A21.53	(2019) Ductile-Iron Compact Fittings for Water Service
AWWA C219	(2017) Bolted Sleeve-Type Couplings for Plain-End Pipe
AWWA C500	(2019) Metal-Seated Gate Valves for Water

Supply Service

AWWA C502	(2018) Dry-Barrel Fire Hydrants
AWWA C509	(2015) Resilient-Seated Gate Valves for Water Supply Service
AWWA C515	(2020) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C605	(2021) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVC0) Pressure Pipe and Fittings
AWWA C606	(2022) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C655	(2009) Field Dechlorination
AWWA C800	(2021) Underground Service Line Valves and Fittings
AWWA C900	(2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA M11	(2016) Steel Pipe: A Guide for Design and Installation
AWWA M23	(2020) Manual: PVC Pipe - Design and Installation - Third Edition
AWWA M41	(2009; 3rd Ed) Ductile-Iron Pipe and Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563	(2021; E 2022a) Standard Specification for Carbon and Alloy Steel Nuts
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for

Poly(Vinyl Chloride) (PVC), Plastic Pipe,
Schedules 40, 80, and 120

ASTM D2241 (2015) Standard Specification for
Poly(Vinyl Chloride) (PVC) Pressure-Rated
Pipe (SDR Series)

ASTM D2466 (2017) Standard Specification for
Poly(Vinyl Chloride) (PVC) Plastic Pipe
Fittings, Schedule 40

ASTM D2467 (2015) Standard Specification for
Poly(Vinyl Chloride) (PVC) Plastic Pipe
Fittings, Schedule 80

ASTM D2855 (2015) Standard Practice for Making
Solvent-Cemented Joints with Poly(Vinyl
Chloride) (PVC) Pipe and Fittings

ASTM D3139 (2019) Joints for Plastic Pressure Pipes
Using Flexible Elastomeric Seals

ASTM F477 (2014; R 2021) Standard Specification for
Elastomeric Seals (Gaskets) for Joining
Plastic Pipe

ASTM F1674 (2011) Standard Test Method for Joint
Restraint Products for Use with PVC Pipe

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24 (2022) Standard for the Installation of
Private Fire Service Mains and Their
Appurtenances

NSF INTERNATIONAL (NSF)

NSF/ANSI 14 (2022) Plastics Piping System Components
and Related Materials

NSF/ANSI 61 (2022) Drinking Water System Components -
Health Effects

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-600-01 (2016; with Change 6, 2021) Fire
Protection Engineering for Facilities

UNDERWRITERS LABORATORIES (UL)

UL 246 (2011; Reprint Jul 2020) UL Standard for
Safety Hydrants for Fire-Protection Service

UL 262 (2004; Reprint Oct 2023) Gate Valves for
Fire-Protection Service

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-PUB-08 (2016) Tapping Guide for PVC Pressure Pipe

1.2 DEFINITIONS

1.2.1 Water Mains

Water mains include water piping having diameters 4 through 14 inch, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.2 Water Service Lines

Water service lines include water piping from a water main to a building service at a point approximately 5 feet from building or the point indicated on the drawings, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.3 Additional Definitions

For additional definitions refer to the definitions in the applicable referenced standard.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Connections; G, R0

SD-03 Product Data

Pipe, Fittings, Joints and Couplings; G, R0

Valves; G, R0

Valve Boxes; G, R0

Fire Hydrants; G, R0

Pipe Restraint; G, R0

Tapping Sleeves; G, R0

Precast Concrete Thrust Blocks; G, R0

Disinfection Procedures; G, R0

SD-06 Test Reports

Bacteriological Samples; G, R0

Leakage Test

Hydrostatic Test

SD-07 Certificates

Pipe, Fittings, Joints and Couplings

Lining

Lining for Fittings

Valves

Fire Hydrants

SD-08 Manufacturer's Instructions

Ductile-Iron Piping

PVC Piping

PVC Piping For Service Lines

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

Use **NSF/ANSI 61** or **NSF/ANSI 14** materials for potable water systems to comply with lead free content requirements as defined by the U.S. Safe Drinking Water Act effective January 2014.

Use **NSF 61** for potable water materials for potable water systems.

Comply with **NFPA 24** for materials, installation, and testing of fire main piping and components.

1.4.2 Qualifications

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to site for required pipe markings and damage. Unload and store with minimum handling and in accordance with manufacturer's instructions to prevent cuts, scratches and other damage. Store materials on site in enclosures or under protective covering. Store

plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves, fire hydrants, and other accessories free of dirt and debris or other contaminants.

1.5.2 Handling

Handle pipe, fittings, valves, fire hydrants, and other accessories in accordance with applicable AWWA standard, manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied. Inspect the pipe for defects before installation. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging. Replace defective material without additional expense to the Government. Store rubber gaskets, not immediately installed, under cover or out of direct sunlight.

Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600 and AWWA M41. Handle PVC pipe, fittings, and accessories in accordance with AWWA C605.

PART 2 PRODUCTS

2.1 MATERIALS

All materials are intended for potable water use unless otherwise indicated. Comply with NSF/ANSI 61 or NSF/ANSI 14 for all potable water pipe, fittings and other applicable materials. Provide pipe, fittings and other applicable materials bearing NSF/ANSI 61 or NSF/ANSI 14 markings for potable water service.

Provide all materials in accordance with AWWA C800 and as indicated herein. Provide valves and fittings with pressure ratings equivalent to the pressure ratings of the pipe.

2.1.1 Pipe, Fittings, Joints And Couplings

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

2.1.1.1 Ductile-Iron Piping

2.1.1.1.1 Pipe and Fittings

Pipe, AWWA C151/A21.51, Pressure Class 350 . Flanged pipe, AWWA C115/A21.15. Fittings, AWWA C110/A21.10 or AWWA C153/A21.53; fittings with push-on joint ends are to meet the same requirements as fittings with mechanical-joint ends, except for the factory modified bell design. Provide fittings with pressure ratings equivalent to that of the pipe. Provide compatible pipe ends and fittings for the specified joints. Provide cement-mortar lining, AWWA C104/A21.4, twice the standard thickness on pipe and fittings.

2.1.1.1.2 Joints and Jointing Material

Provide push-on joints or mechanical joints for pipe and fittings. Provide mechanical joints where indicated. Provide flanged joints where indicated. Provide mechanically coupled type joints using a sleeve-type mechanical coupling where indicated. Provide grooved or shouldered type joints where indicated. Provide insulating joints where indicated. Sleeve-type mechanical couplings in lieu of push-on joints are acceptable, subject to the limitations specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS. Utilize grooved or shouldered type joints in lieu of flanged joint or push-on joint, except where joint is buried.

- a. Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly as recommended in [AWWA C111/A21.11](#).
- b. Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets as recommended in [AWWA C111/A21.11](#).
- c. Flanged Joints: Bolts, nuts, and gaskets for flanged connections as recommended in Appendix A of [AWWA C115/A21.15](#). Provide [AWWA C115/A21.15](#) ductile iron flanges and conform to [ASME B16.1](#), Class 125. Provide [ASTM A536](#) epoxy coated steel set screw flanges. Gasket and lubricants for set screw flanges, in accordance with mechanical-joint gaskets specified in [AWWA C111/A21.11](#).
- d. Insulating Joints: Designed to prevent metal-to-metal contact at the joint between adjacent sections of piping. Provide flanged type joint with insulating gasket, insulating bolt sleeves, and insulating washers. Provide full face dielectric type gaskets, as recommended in the Appendix to [AWWA C115/A21.15](#). Bolts and nuts, as recommended in the Appendix to [AWWA C115/A21.15](#).
- e. Sleeve-Type Mechanical Coupled Joints: As specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS.
- f. Shouldered Type Joints: Grooved and shouldered pipe ends and couplings, [AWWA C606](#). Joint dimension as specified in [AWWA C606](#) for rigid joints, joint dimensions as specified in [AWWA C606](#) for flexible joints.

2.1.1.2 Plastic Piping

2.1.1.2.1 PVC Piping

2.1.1.2.1.1 PVC Piping

[AWWA C900](#) plain end or gasket bell end pipe meeting or exceeding [ASTM D1784](#) cell class 12454, with a minimum Pressure Class 150 (DR27.5), , , , with ductile iron outside diameter (DIOD).

2.1.1.2.1.2 Fittings for PVC Pipe

Ductile iron fittings, [AWWA C110/A21.10](#) or compact fittings in accordance with [AWWA C153/A21.53](#), with cement-mortar [lining for fittings](#), [AWWA C104/A21.4](#), standard thickness. Fittings with push-on joint ends are to conform to the same requirements as fittings with mechanical-joint ends, except for the factory modified bell design compatible for use with

PVC pipe as specified.

Fittings from material that meets or exceeds [ASTM D1784](#) cell class 12454 and is the same material as the pipe with elastomeric gaskets, in conformance with [AWWA C605](#) and [AWWA C900](#).

2.1.1.2.1.3 Joints and Jointing Material for PVC

- a. Push-on joints: Use jointing material in accordance with [ASTM D3139](#) and [AWWA C111/A21.11](#) between pipes, pipes and metal fittings, valves, and other accessories or compression-type joints/mechanical joints. Provide each joint connection with an elastomeric gasket compatible for the bell or coupling used. Gaskets for push-on joints for pipe, [ASTM F477](#). Gaskets for push-on joints and compression-type joints/mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories, [AWWA C111/A21.11](#), respectively, for push-on joints and mechanical joints.
- b. Mechanical Joint: Use mechanically coupled joints having a sleeve-type mechanical coupling, as specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS, as an optional jointing method for plain-end PVC pipe, subject to the limitations specified for mechanically coupled joints using a sleeve-type mechanical coupling as specified for compression-type joints in [ASTM D3139](#). Provide jointing material in accordance with [AWWA C111/A21.11](#) between pipe and sleeve-type mechanical couplings.

2.1.1.2.2 PVC Piping for Service Lines

2.1.1.2.2.1 Pipe and Fittings

Provide [ASTM D1784](#) cell class 12454 pipe and fittings of the same PVC material.

- a. [ASTM D1785](#), Schedule 40 with [ASTM D2466](#) Schedule 40 or [ASTM D2467](#) Schedule 80 fittings.
- b. [ASTM D2241](#) pipe and fittings with SDR as necessary to provide 150 psi minimum pressure rating with [ASTM D2466](#) Schedule 40 or [ASTM D2467](#) Schedule 80 fittings.

2.1.1.2.2.2 Joints and Connections

Fittings may be joined by the solvent-cement method or threading.

2.1.1.2.2.3 Solvent Joining

Provide solvent joints in accordance with [ASTM D2855](#).

2.1.2 Valves

2.1.2.1 Gate Valves 3 Inch Size and Larger on Buried Piping

[AWWA C500](#), [AWWA C509](#), [AWWA C515](#), or [UL 262](#) and:

- a. [AWWA C500](#): nonrising stem type with double-disc gate and mechanical-joint ends or push-on joint ends compatible for the adjoining pipe

- b. AWWA C509 or AWWA C515: nonrising stem type with mechanical-joint ends
- c. UL 262: inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 175 psi, and have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined.

Match materials for UL 262 gate valves to the reference standards specified in AWWA C500. Gate valves open by counterclockwise rotation of the valve stem. Stuffing boxes have O-ring stem seals, except for those valves for which gearing is specified, in which case use conventional packing in place of O-ring seal. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Provide valve ends and gaskets for connection to sleeve-type mechanical couplings that conform to the requirements specified for the joint or coupling. Provide all valves from one manufacturer.

2.1.2.2 Gate Valves 3 Inch Size and Larger in Valve Pit(s)

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

- a. AWWA C500: outside-screw-and-yoke rising-stem type with double-disc gates and flanged ends
- b. AWWA C509 or AWWA C515: outside-screw-and-yoke rising-stem type with flanged ends
- c. UL 262: outside-screw-and-yoke type, with double-disc or split-wedge type gate and flanged ends, and designed for a hydraulic working pressure of 175 psi

Match materials for UL 262 gate valves to the reference standards specified in AWWA C500. 6 inch Gate valves are nonrising stem type or inside-screw type . Provide gate valves with handwheels that open by counterclockwise rotation of the valve stem. Bolt and construct stuffing boxes so as to permit easy removal of parts for repair. In lieu of flanged ends, provide valves with grooved or shouldered ends compatible with grooved or shouldered type joints, as specified in the paragraph DUCTILE-IRON PIPING. Provide all valves from one manufacturer.

2.1.2.3 Valve Boxes

Provide a valve box for each gate valve on buried piping. Construct adjustable valve boxes manufactured from precast concrete of a size compatible for the valve on which it is used. Provide a round head. Cast the word "WATER" on the lid. The minimum diameter of the shaft of the box is 5 1/4 inches. Provide precast concrete boxes installed in locations subjected to vehicular traffic. Manufacture precast concrete boxes in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION.

2.1.2.4 Valve Pits

Construct the valve pits at locations indicated or as required above and in accordance with the details shown.

2.1.3 Fire Hydrants

2.1.3.1 Fire Hydrants

Provide fire hydrants where indicated. Paint fire hydrants with at least one coat of primer and two coats of enamel paint. Paint barrel and bonnet colors in accordance with [UFC 3-600-01](#). Stencil fire hydrant number and main size on the fire hydrant barrel using black stencil paint.

2.1.3.1.1 Dry-Barrel Type Fire Hydrants

Provide Dry-barrel type fire hydrants, [AWWA C502](#) or [UL 246](#), "Base Valve" with 6 inch inlet, 5 1/4 inch valve opening, one 4 1/2 inch pumper connection, and two 2 1/2 inch hose connections. Provide

Provide mechanical-joint end only inlet , except where flanged end is indicated; with end matching requirements as specified in [AWWA C502](#) or [UL 246](#) for size and shape of operating nut, cap nuts, and threads on hose and pumper connections. Provide fire hydrants with frangible sections as mentioned in [AWWA C502](#) . Provide fire hydrant with special couplings joining upper and lower sections of fire hydrant barrel that break from a force imposed by a moving vehicle.

2.1.4 Disinfection

Chlorinating materials are to conform to: Chlorine, Liquid: [AWWA B301](#); Hypochlorite, Calcium and Sodium: [AWWA B300](#).

2.2 ACCESSORIES

2.2.1 Pipe Restraint

2.2.1.1 Precast Thrust Blocks

Provide [precast concrete thrust blocks](#).

2.2.1.2 Joint Restraint

Provide restrained joints in accordance with [NFPA 24](#), Chapter 10 and in accordance with [ASTM F1674](#).

Provide mechanical joint restraint or metal harness fabricated by the pipe manufacturer.

2.2.2 Protective Enclosures

Provide Freeze-Protection Enclosures that are insulated and designed to protect aboveground water piping, equipment, or specialties from freezing and damage.

2.2.2.1 Housing

Reinforced and insulated aluminum construction; with anchoring devices for attaching housing to concrete base, access doors with locking devices, sized to allow access and service of the protected unit, drain openings, and an electric heating cable or heater with self-limiting temperature control.

2.2.3 Tapping Sleeves

Provide cast gray, ductile, malleable iron or stainless steel, split-sleeve type tapping sleeves of the sizes indicated for connection to existing main with flanged or grooved outlet, and with bolts, follower rings and gaskets on each end of the sleeve. Utilize similar metals for bolts, nuts, and washers to minimize the possibility of galvanic corrosion. Provide dielectric gaskets where dissimilar metals adjoin. Provide a tapping sleeve assembly with a maximum working pressure of 150 psi. Provide bolts with square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, utilize an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pre-torqued to 50 foot-pound.

2.2.4 Sleeve-Type Mechanical Couplings

Use AWWA C219 couplings to join plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling consists of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. Provide true circular middle ring and the follower rings sections free from irregularities, flat spots, and surface defects; provide for confinement and compression of the gaskets. For ductile iron and PVC pipe, use ASTM A536 ductile iron. Use gaskets for resistance to set after installation and to meet the requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Provide track-head type bolts ASTM A307, Grade A, with ASTM A563, Grade A nuts or round-head square-neck type ASME B18.5.2.2M or ASME B18.5.2.1M bolts with ASME B18.2.2 hex nuts. Provide 5/8 inch diameter bolts. Shape bolt holes in follower rings to hold fast to the necks of the bolts used. Do not use mechanically coupled joints using a sleeve-type mechanical coupling as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Provide a tight flexible joint with mechanical couplings under reasonable conditions, such as pipe movements caused by expansion, contraction, slight settling or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Match coupling strength to that of the adjoining pipeline.

2.2.5 Insulating Joints

Provide a rubber-gasketed insulating joint or dielectric coupling between pipe of dissimilar metals which will effectively prevent metal-to-metal contact between adjacent sections of piping.

2.2.6 Bonded Joints

For all ferrous pipe, provide a metallic bond at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of ferrous metallic piping to effect continuous conductivity. Provide Size 1/0 copper conductor thermal weld type bond wire designed for direct burial and shaped to stand clear of the joint.

2.2.7 Dielectric Fittings

Install dielectric fittings between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains to prevent metal-to-metal contact of dissimilar metallic piping elements and compatible with the indicated working pressure.

2.2.8 Tracer Wire for Nonmetallic Piping

Provide a continuous bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length over each separate run of nonmetallic pipe.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Connections to Existing System

Perform all connections to the existing water system in the presence of the Contracting Officer.

3.1.2 Operation of Existing Valves

Do not operate valves within or directly connected to the existing water system unless expressly directed to do so by the Contracting Officer.

3.1.3 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2 INSTALLATION

Install all materials in accordance with the applicable reference standard, manufacturers instructions and as indicated herein.

3.2.1 Piping

3.2.1.1 General Requirements

Install pipe, fittings, joints and couplings in accordance with the applicable referenced standard, the manufacturer's instructions and as specified herein.

3.2.1.1.1 Termination of Water Lines

Terminate the work covered by this section at a point approximately 5 feet from the building, unless otherwise indicated.

Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility. Where nonferrous metallic pipe (i.e., copper tubing) crosses any ferrous piping, provide a minimum vertical separation of 12 inches between pipes.

3.2.1.1.2 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into

trenches. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches. Cut pipe cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material. Blocking or wedging between bells and spigots is not permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at the design elevation and grade. Secure firm, uniform support. Wood support blocking is not permitted. Lay pipe so that the full length of each section of pipe and each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports for fastening work into place. Make provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been assembled. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Provide a minimum of 3 feet depth of cover over top of pipe.

3.2.1.1.3 Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.2.1.1.4 Connections to Existing Water Lines

Make connections to existing water lines after coordination with the facility and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped and as indicated.

3.2.1.1.5 Sewer Manholes

No water piping is to pass through or come in contact with any part of a sewer manhole.

3.2.1.1.6 Water Piping Parallel With Sewer Piping

Where the location of the water line is not clearly defined by dimensions on the drawings, do not lay water line closer than 10 feet, horizontally, from any sewer line.

3.2.1.1.7 Water Piping Crossing Sewer Piping

Provide at least 18 inches above the top (crown) of the sewer piping and the bottom (invert) of the water piping whenever possible. Measure the distance edge-to-edge. Where water lines cross under gravity sewer lines, construct sewer line of AWWA compliant ductile iron water piping with rubber-gasketed joints and no joint located within 10 feet, horizontally, of the crossing.

3.2.1.1.8 Penetrations

Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures. Fill annular space between walls and sleeves with rich cement mortar. Fill annular space between pipe and sleeves with mastic.

3.2.1.2 Ductile-Iron Piping

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C600 for pipe installation, joint assembly, valve-and-fitting installation, and thrust restraint.

- a. Jointing: Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. Make flanged joints with the gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fitting has dimensions that do not allow the making of a flanged joint as specified, replace it. Use set screw flanges to make flanged joints where conditions prevent the use of full-length flanged pipe and assemble in accordance with the recommendations of the set screw flange manufacturer. During installation of set screw gasket provide for confinement and compression of gasket when joint to adjoining flange is made. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer. Make grooved type joints with the couplings previously specified for this type joint connecting pipe with the grooved ends specified for this type joint; assemble in accordance with the recommendations of the coupling manufacturer. Groove pipe in the field only with groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint. Make insulating joints with the gaskets, sleeves, washers, bolts, and nuts previously specified for this type joint. Assemble insulating joints as specified for flanged joints, except that bolts with insulating sleeves are to be full size for the bolt holes. Ensure that there is no metal-to-metal contact between dissimilar metals after the joint has been assembled.
- b. Allowable Deflection: Follow AWWA C600 and AWWA M41 for the maximum allowable deflection. If the alignment requires deflection in excess of the above limitations, provide special bends or a sufficient number of shorter lengths of pipe to achieve angular deflections within the limit set forth.
- c. Exterior Protection: Completely encase buried ductile iron pipelines using Method A or B , with polyethylene film, in accordance with AWWA C105/A21.5.

3.2.1.3 PVC Water Main Pipe

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C605 for laying of pipe, joining PVC pipe to fittings and accessories, setting of fire hydrants, valves, and fittings; and with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, Chapter 7,

"Installation."

- a. Jointing: Make push-on joints with the elastomeric gaskets specified for this type joint, using either elastomeric-gasket bell-end pipe or elastomeric-gasket couplings. For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel; for push-on joint connections to metal fittings, valves, and other accessories, cut spigot end of pipe off square and re-bevel pipe end to a bevel approximately the same as that on ductile-iron pipe used for the same type of joint. Use a lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of [AWWA C605](#) for laying the pipe and the recommendations in [AWWA M23](#), Chapter 7, "Installation," for pipe joint assembly. Assemble push-on joints for connection to fittings, valves, and other accessories in accordance with the requirements of [AWWA C605](#) for joining PVC pipe to fittings and accessories and with the requirements of [AWWA C600](#) for joint assembly. Make compression-type joints/mechanical joints with the gaskets, glands, bolts, nuts, and internal stiffeners previously specified for this type joint; assemble in accordance with the requirements of [AWWA C605](#) for joining PVC pipe to fittings and accessories, with the requirements of [AWWA C600](#) for joint assembly, and with the recommendations of Appendix A to [AWWA C111/A21.11](#). Cut off spigot end of pipe for compression-type joint/mechanical-joint connections and do not re-bevel. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer using internal stiffeners as previously specified for compression-type joints.
- b. Joint Offset: Construct joint offset in accordance [AWWA C605](#). Do not exceed the minimum longitudinal bending as indicated by [AWWA C605](#).
- c. Fittings: Install in accordance with [AWWA C605](#).

3.2.1.4 Fire Protection Service Lines for Sprinkler Supplies

Connect water service lines used to supply building sprinkler systems for fire protection to the water main in accordance with [NFPA 24](#).

3.2.1.5 Water Service Piping

3.2.1.5.1 Location

Connect water service piping to the building service where the building service has been installed. Where building service has not been installed, terminate water service lines approximately 5 feet from the building line at the points indicated; close such water service lines with plugs or caps.

3.2.1.5.2 Water Service Line Connections to Water Mains

Connect 4 and 6 inch water service lines to the main with a rigid connection and install a gate valve on service line below the frostline as indicated. Connect water service lines to ductile-iron water mains in accordance with [AWWA C600](#) for service taps. Connect water service lines to PVC water mains in accordance with [UBPPA UNI-PUB-08](#) and the recommendations of [AWWA M23](#), Chapter 9, "Service Connections." Connect water service lines to steel water mains in accordance with the recommendations of the steel water main pipe manufacturer and with the

recommendations for special and valve connections and other appurtenances in AWWA M11, Chapter 13, "Supplementary Design Data and Details."

3.2.2 Disinfection

Prior to disinfection, provide disinfection procedures, proposed neutralization and disposal methods of waste water from disinfection as part of the disinfection submittal. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Disinfect new water piping using the AWWA C651 continuous-feed method of chlorination . Ensure a free chlorine residual of not less than 10 parts per million after 24 hour holding period and prior to performing bacteriological tests.

3.2.3 Flushing

Perform bacteriological tests prior to flushing. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 parts per million, the residual chlorine content of the distribution system, or acceptable for domestic use. Use AWWA C655 neutralizing chemicals.

3.2.4 Pipe Restraint

3.2.4.1 Concrete Thrust Blocks

Install concrete thrust blocks where indicated.

3.2.4.2 Restrained Joints

Install restrained joints in accordance with NFPA 24 where indicated. For metal harness use tie rods and clamps as shown in NFPA 24. Provide structural welded, skip welded, clamp type harness, bell bolt harness, snap ring harness for pipe anchorage. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe.

3.2.5 Valves

3.2.5.1 Gate Valves

Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515. Install gate valves on PVC water mains in accordance with the recommendations for appurtenance installation in AWWA M23, Chapter 7, "Installation." Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.6 Fire Hydrants

Install fire hydrants, except for metal harness, in accordance with AWWA C600 for fire hydrant installation and as indicated. Make and assemble joints as specified for making and assembling the same type joints between pipe and fittings. Provide metal harness as specified

under pipe anchorage requirements for the respective pipeline material to which fire hydrant is attached. Install fire hydrants with the 4 1/2 inch connections facing the adjacent paved surface. If there are two paved adjacent surfaces, install fire hydrants with the 4 1/2 inch connection facing the paved surface where the connecting main is located.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

Notify the Contracting Officer a minimum of five days in advance of hydrostatic testing. Coordinate the proposed method for disposal of waste water from hydrostatic testing. Perform field tests, and provide labor, equipment, and incidentals required for testing, except that water needed for field tests will be furnished as set forth in paragraph AVAILABILITY AND USE OF UTILITY SERVICES in Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Provide documentation that all items of work have been constructed in accordance with the Contract documents.

3.3.1.1 Hydrostatic Test

Test the water system in accordance with the applicable AWWA standard specified below. Where water mains provide fire service, test in accordance with the special testing requirements given in the paragraph SPECIAL TESTING REQUIREMENTS FOR FIRE SERVICE. Test ductile-iron water mains in accordance with the requirements of AWWA C600 for hydrostatic testing. The amount of leakage on ductile-iron pipelines with mechanical-joints or push-on joints is not to exceed the amounts given in AWWA C600; no leakage will be allowed at joints made by any other methods. Test PVC plastic water systems made with PVC pipe in accordance with the requirements of AWWA C605 for pressure and leakage tests. The amount of leakage on pipelines made of PVC water main pipe is not to exceed the amounts given in AWWA C605, except that at joints made with sleeve-type mechanical couplings, no leakage will be allowed. Test steel water mains in accordance with applicable requirements of AWWA C600 for hydrostatic testing. The amount of leakage on steel pipelines with rubber-gasketed bell-and-spigot joints is not to exceed 20 gallons per 24 hours per inch of pipe diameter per mile of pipeline; no leakage will be allowed at joints made by any other method. To stop leakage, repair welded joints only by welding. Test water service lines in accordance with requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at plastic service pipe joints, flanged joints, and screwed joints. Do not backfill utility trench or begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 7 days after placing of the concrete.

3.3.1.2 Leakage Test

For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

3.3.1.3 Bacteriological Testing

Perform bacteriological tests in accordance with AWWA C651 Option A . For new water mains use Option A and obtain two sets of samples for coliform analysis, each sample being collected at least 16 hours apart. Take samples every 1,200 ft plus one set from the end of the line and at least one from each branch greater than one pipe length. Analyze samples by a

certified laboratory, and submit the results of the [bacteriological samples](#).

3.3.1.4 Special Testing Requirements for Fire Service

Test water mains and water service lines providing fire service or water and fire service in accordance with [NFPA 24](#). The additional water added to the system must not exceed the limits given in [NFPA 24](#)

3.3.1.5 Tracer Wire Continuity Test

Test tracer wire for continuity after service connections have been completed and prior to final pavement or restoration. Verify that tracer wire is locatable with electronic utility locating equipment. Repair breaks or separations and re-test for continuity.

3.4 SYSTEM STARTUP

Water mains and appurtenances must be completely installed, disinfected, flushed, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Obtain approval by the Contracting Officer prior to the new water piping being placed into service.

3.5 CLEANUP

Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

-- End of Section --

SECTION 33 30 00

SANITARY SEWERAGE

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION
(AREMA)

AREMA Eng Man (2017) Manual for Railway Engineering

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4 (2022) Cement-Mortar Lining for
Ductile-Iron Pipe and Fittings for Water

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

AWWA C600 (2017) Installation of Ductile-Iron Mains
and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M (2003; R 2021) Standard Specification for
Gray Iron Castings

ASTM A123/A123M (2017) Standard Specification for Zinc
(Hot-Dip Galvanized) Coatings on Iron and
Steel Products

ASTM A536 (1984; R 2019; E 2019) Standard
Specification for Ductile Iron Castings

ASTM A746 (2018; R 2022) Standard Specification for
Ductile Iron Gravity Sewer Pipe

ASTM C33/C33M (2023) Standard Specification for Concrete
Aggregates

ASTM C94/C94M (2023) Standard Specification for
Ready-Mixed Concrete

ASTM C150/C150M (2022) Standard Specification for Portland
Cement

ASTM C270 (2019a; E 2019) Standard Specification for
Mortar for Unit Masonry

ASTM C443 (2021) Standard Specification for Joints
for Concrete Pipe and Manholes, Using

Rubber Gaskets

ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C972	(2000; R 2011) Compression-Recovery of Tape Sealant
ASTM D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D624	(2000; R 2020) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2412	(2021) Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F794	(2021) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27	(Nov 2016) Scaffolds and Roope Descent

Systems

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6

(1998) Recommended Practice for
Low-Pressure Air Testing of Installed
Sewer Pipe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor's License; G, R0

SD-02 Shop Drawings

Installation Drawings; G, R0

SD-03 Product Data

Precast Concrete Manholes

Frames, Covers, and Gratings

Gravity Pipe

SD-06 Test Reports

Low-Pressure Air Tests; G, R0

Deflection Testing

SD-07 Certificates

Portland Cement

Gaskets

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing Contractor's License is current and state certified or state registered.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Check upon arrival; identify and segregate as to types, functions, and

sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.4.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.4.1.2 Cement, Aggregate, and Reinforcement

As specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

1.4.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Carry, do not drag, pipe to trench. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe in accordance with the manufacturer's recommendation and discard those materials if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Sanitary Sewer Gravity Pipeline

Provide mains and laterals of polyvinyl chloride (PVC) plastic pipe. Provide building connections 6 inch lines of polyvinyl chloride (PVC) plastic pipe. Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 5 feet outside of building walls.

2.2 MATERIALS

Provide materials conforming to the respective specifications and other requirements specified below. Submit manufacturer's product specification, standard drawings or catalog cuts.

2.2.1 Gravity Pipe

2.2.1.1 Ductile Iron Gravity Sewer Pipe and Associated Fittings

2.2.1.1.1 Ductile Iron Gravity Pipe and Fittings

Provide ductile iron pipe conforming to ASTM A746 with cement-mortar lining in conforming to AWWA C104/A21.4, Pressure Class 350. Provide push-on joints conforming to AWWA C111/A21.11.

2.2.1.2 PVC Gravity Sewer Piping

2.2.1.2.1 PVC Gravity Pipe and Fittings

ASTM F949 with ends suitable for elastomeric gasket joints. ASTM F794, Series 46, for ribbed sewer pipe with smooth interior, size 4 inch through 48 inch diameters.

2.2.1.2.2 PVC Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Gaskets are to conform to ASTM F477.

2.2.2 Cement Mortar

Provide cement mortar conforming to ASTM C270, Type M with Type II cement.

2.2.3 Portland Cement

Submit certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings, septic tanks, and precast manholes. Provide portland cement conforming to ASTM C150/C150M, Type II for concrete used in concrete pipe, concrete pipe fittings, septic tanks, and manholes and type optional for cement used in concrete cradle, concrete encasement, and thrust blocking. ,Use a cement containing less than 0.60 percent alkalis where aggregates are alkali reactive, as determined by Appendix XI of ASTM C33/C33M.

2.2.4 Portland Cement Concrete

Provide portland cement concrete conforming to ASTM C94/C94M, compressive strength of 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement is to have a compressive strength of 2500 psi minimum at 28 days. Protect concrete in place from freezing and moisture loss for 7 days.

2.2.5 Precast Concrete Manholes

Provide precast concrete manholes, risers, base sections, and tops conforming to ASTM C478 and be manufactured in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION; base and first riser are to be monolithic.

2.2.6 Gaskets and Connectors

Provide gaskets for joints between manhole sections conforming to ASTM C443. Resilient connectors for making joints between manhole and pipes entering manhole are to conform to ASTM C923 or ASTM C990.

2.2.7 External Preformed Rubber Joint Seals

An external preformed rubber joint seal is an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" are to be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal is to be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of 60 mils.

Each unit is to consist of a top and bottom section and have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic is to be a non-hardening butyl rubber sealant and seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections are to cover up to two more adjusting rings. Properties and values are listed in the following table:

Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals				
Physical Properties	Test Methods	EPDM	Neoprene	Butyl Mastic
Tensile, psi	ASTM D412	1840	2195	--
Elongation, percent	ASTM D412	553	295	350
Tear Resistance, pli	ASTM D624 (Die B)	280	160	--
Rebound, percent, 5 minutes	ASTM C972 (mod.)	--	--	11
Rebound, percent, 2 hours	ASTM C972	--	--	12

2.2.8 Frames, Covers, and Gratings for Manholes

Frame and cover are to be cast gray iron, ASTM A48/A48M, Class 35B, cast ductile iron, ASTM A536, Grade 65-45-12, or reinforced concrete, ASTM C478 ASTM C478M. Frames and covers are to be circular without vent holes. Size are to be for 24 inch opening. Stamp or cast the words "Sanitary Sewer" into covers so that it is plainly visible.

2.2.9 Manhole Steps

Zinc-coated steel conforming to 29 CFR 1910.27 with a plastic coating pressure-molded to the steel is to be used. Provide plastic coating conforming to ASTM D4101, copolymer polypropylene. Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 4 feet deep.

2.2.10 Manhole Ladders

Provide a steel ladder where the depth of a manhole exceeds 12 feet. The ladder is not to be less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers are to be a minimum 3/8 inch thick and 2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Installation Drawings

Submit Installation Drawings showing complete detail, both plan and side

view details with proper layout and elevations.

3.2 INSTALLATION

Backfill after inspection by the Contracting Officer. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer.

3.2.1 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.2.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.2.2.1 Location

Terminate the work covered by this section at a point approximately 5 feet from the building. Install pressure sewer lines beneath water lines only, with the top of the sewer line being at least 2 feet below bottom of water line. When these separation distances can not be met, contact the Contracting Officer for direction.

3.2.2.1.1 Sanitary Sewer Manholes

No water piping must pass through or come in contact with any part of a sanitary sewer manhole.

3.2.2.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell ends in the upgrade direction. Adjust spigots in bells to give a uniform space all around. Blocking or wedging between bells and spigots will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Construct branch connections by use of regular fittings or solvent cemented saddles as approved. Provide saddles for PVC pipe conforming to Table 4 of ASTM D3034.

3.2.3 Special Requirements

3.2.3.1 Installation of Ductile Iron Gravity Sewer Pipe

Unless otherwise specified, install pipe and associated fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of [AWWA C600](#) for pipe installation and joint assembly.

- a. Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of [AWWA C600](#) for joint assembly. Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint and assemble in accordance with the applicable requirements of [AWWA C600](#) for joint assembly and the recommendations of Appendix A to [AWWA C111/A21.11](#).

3.2.3.2 Installation of PVC Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of [ASTM D2321](#) for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of [ASTM D2321](#) for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.3.3 Installation of Dual Wall and Triple Wall Polypropylene

Install pipe in accordance with "General Requirements for installation of Pipelines" of this section, with the polypropylene pipe manufacturer's recommendations, and with the requirements of [ASTM D2321](#) for laying and joining pipe and fittings. Place a minimum of 6 inches of Class 1 or Class 2 backfill over the crown of the pipe with minimum 90 percent compaction.

3.2.3.4 Pipeline Installation Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, install piping in accordance with the specifications for pipelines conveying nonflammable substances in [AREMA Eng Man](#).

3.2.4 Concrete Work

Cast-in-place concrete is included in Section [03 30 00](#) CAST-IN-PLACE CONCRETE. Support the pipe on a concrete cradle, or encased in concrete where indicated or directed.

3.2.5 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction,

make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Perform cast-in-place concrete work in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.2.6 Miscellaneous Construction and Installation

3.2.6.1 Connecting to Existing Manholes

Connect pipe to existing manholes such that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. Center the connection on the manhole. Holes for the new pipe are to be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cut the manhole in a manner that will cause the least damage to the walls.

3.2.6.2 Metal Work

3.2.6.2.1 Workmanship and Finish

Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

3.2.6.2.2 Field Painting

After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal, remove mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.3 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.3.1 Tests

Perform field tests and provide labor, equipment, and incidentals required for testing.

3.3.1.1 Leakage Tests for Nonpressure Lines

Test lines for leakage by either or by low-pressure air tests. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

3.3.1.1.1 Low-Pressure Air Tests

3.3.1.1.1.1 PVC Pipelines

Test PVC pipe in accordance with [UBPPA UNI-B-6](#). The allowable pressure drop is located in [UBPPA UNI-B-6](#). Make calculations in accordance with the Appendix to [UBPPA UNI-B-6](#).

3.3.1.2 Deflection Testing

Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads determined in accordance with [ASTM D2412](#). Deflection of pipe in the installed pipeline under external loads is not to exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

3.3.1.2.1 Pull-Through Device

This device is to be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Space circular sections on the shaft so that the distance from external faces of front and back sections will equal or exceed the diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided the device meets the applicable requirements specified in this paragraph, including those for diameter of the device, and that the mandrel has a minimum of 9 arms. Ball, cylinder, or circular sections are to conform to the following:

- a. A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.
- b. Homogeneous material throughout, is to have a density greater than 1.0 as related to water at 39.2 degrees F, and a surface Brinell hardness of not less than 150.
- c. Center bored and through-bolted with a 1/4 inch minimum diameter steel shaft having a yield strength of not less than 70,000 psi, with eyes or loops at each end for attaching pulling cables.
- d. Suitably Back each eye or loop with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

3.3.1.2.2 Deflection Measuring Device

Sensitive to 1.0 percent of the diameter of the pipe being tested and be accurate to 1.0 percent of the indicated dimension. Prior approval is required for the deflection measuring device.

3.3.1.2.3 Pull-Through Device Procedure

Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions.

3.3.1.2.4 Deflection measuring device procedure

Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, replace pipe which has excessive deflection and completely retest in same manner and under same conditions.

3.3.2 Field Tests for Cast-In-Place Concrete

Field testing requirements are covered in Section 03 30 00 CAST-IN-PLACE CONCRETE

3.3.3 Inspection

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; the light must show a practically full circle of light through the pipeline when viewed from the adjoining end of line.

-- End of Section --

SECTION 33 31 23.00 10

SANITARY SEWER FORCE MAIN PIPING

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO HB-17 (2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

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

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

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C110/A21.10 (2021) Ductile-Iron and Gray-Iron Fittings

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

AWWA C115/A21.15 (2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges

AWWA C151/A21.51 (2017) Ductile-Iron Pipe, Centrifugally Cast

AWWA C200 (2012) Steel Water Pipe - 6 In. (150 mm) and Larger

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

AWWA C207 (2018) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm)

AWWA C210 (2015) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines

AWWA C600 (2017) Installation of Ductile-Iron Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M (2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM D3308 (2012; R 2017) Standard Specification for PTFE Resin Skived Tape

DUCTILE IRON PIPE RESEARCH ASSOCIATION (DIPRA)

DIPRA TRD (2016) Thrust Restraint Design for Ductile Iron Pipe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Disposal of Waste Water

Final Test Report

1.3 DELIVERY, STORAGE, AND HANDLING

Do not damage pipe, fittings and accessories, and pipe coatings during delivery, handling, and storage.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

Provide piping in locations and sizes as specified in the following table. Also conform to the respective specifications and other requirements specified below

Location	Piping Size Range	Piping Material

Location	Piping Size Range	Piping Material
Force Mains	4 inches in diameter and larger	Ductile Iron

2.1.1 Ductile Iron Pipe

2.1.1.1 Ductile Iron Pipe

AWWA C151/A21.51, working pressure not less than 150 psi, unless otherwise shown or specified.

2.1.1.2 Fittings, Mechanical

AWWA C110/A21.10, rated for 150 psi.

2.1.1.3 Fittings, Push-On

AWWA C110/A21.10 and AWWA C111/A21.11, rated for 150 psi.

2.1.2 Steel Pipe

2.1.2.1 Steel Pipe Less Than 6 inches Diameter

ASTM A53/A53M, standard weight, threaded end, galvanized.

2.1.2.2 Fittings Less Than 6 inches Diameter

ASME B16.3, galvanized.

2.2 JOINTS

2.2.1 Ductile Iron Piping

2.2.1.1 Push-on Joints

AWWA C111/A21.11.

2.2.1.2 Mechanical Joints

AWWA C111/A21.11 as modified by AWWA C151/A21.51.

2.2.1.3 Flanged Joints

AWWA C115/A21.15.

2.2.2 Steel Piping

2.2.2.1 Push-on Joints

AWWA C200.

2.2.2.2 Mechanical Joints

AWWA C200.

2.2.2.3 Flanged Joints

AWWA C207.

2.3 VALVES

2.3.1 Check Valves

2.3.1.1 Ball Check Valves

Provide iron-bodied ball check valves, with flanged ends, that are of the non-slam type. Provide 125 pound type flanges complying with ASME B16.1 with stainless steel ball unless otherwise specified.

2.3.2 Air Release Valves

Provide air release valves designed to permit release of air from an empty pipe during filling and capable of discharging accumulated air in the line while the line is in operation and under pressure. Attach valves by means of threaded pipe connections. Vent valves to the atmosphere.

2.3.2.1 Manual Air Release Valves

Consisting of an 2 inch ball valve and 2 inch stainless steel pipe and fittings. Install the valve with its line of flow in the horizontal position.

2.4 VALVE VAULTS

Concrete, except design concrete vaults installed in locations subject to vehicular traffic to withstand the following H-20 AASHTO load designation as outlined in AASHTO HB-17. Manufacture concrete vaults accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION. Cast the word "SEWER" in the cover. Provide secure latch/lock mechanism to prevent unauthorized entry or tampering with the components within.

2.5 MISCELLANEOUS MATERIALS

Provide miscellaneous materials in compliance with the following requirements:

2.5.1 Pipe Coatings and Linings

- a. Steel, interior: AWWA C203 or AWWA C210.
- b. Steel, exterior, buried: AWWA C203.
- c. Steel, exterior, exposed: AWWA C210.

2.5.2 Joint Lubricants

Provide joint lubricants as recommended by the pipe manufacturer.

2.5.3 Bolts, Nuts and Glands

AWWA C111/A21.11.

2.5.4 Joint Compound

A stiff mixture of graphite and oil or inert filler and oil.

2.5.5 Joint Tape

ASTM D3308.

2.5.6 Bond Wire

Bond wire type RHW or USE, Size 1/0 AWG, neoprene jacketed copper conductor shaped to stand clear of the joint.

PART 3 EXECUTION

3.1 INSTALLATION

Install pipe, pipe fittings, and appurtenances at the locations indicated. Perform excavation, trenching, and backfilling as specified in Section 31 00 00 EARTHWORK.

3.1.1 Cutting

Cut pipe in a neat manner with mechanical cutters. Use wheel cutters where practicable. Grind sharp and rough edges smooth and remove loose material from the pipe before laying.

3.1.2 Laying

Except where otherwise authorized, lay pipe with bells facing the direction of laying. Before lowering and while suspended, inspect the pipe for defects. Reject defective material. Lay pipe in compliance with the following:

Ductile Iron	AWWA C600
Steel	AWWA C600

Reinforced Thermosetting Resin	Manufacturer's instructions
Reinforced Plastic Mortar	Manufacturer's instructions

3.1.3 Jointing

3.1.3.1 Joints for Ductile Iron Pipe

Install mechanical and push-on type joints in compliance with [AWWA C600](#) and the manufacturer's instructions. Install flanged joints in compliance with manufacturer's instructions.

3.1.3.2 Joints for Steel Pipe

Make screw joints tight with joint tape or joint compound applied with a brush to the male threads only. Install mechanical joints, push-on joints, and flanged joints in compliance with the manufacturer's instructions.

3.1.4 Coating and Lining

Field coat non-galvanized steel pipe in compliance with [AWWA C203](#). Test the applied materials by means of a spark-type electrical device in compliance with [AWWA C203](#). Repair flaws and holidays in the coating or lining of the pipe and the pipe joints; with the repaired areas at least equal in thickness to the minimum required for the pipe.

3.1.5 Installation of Valves

Prior to installation, clean valves of all foreign matter and inspect for damage and then fully open and close valves to ensure that all parts are properly operating. Install valves with the stem in the vertical position. Install valves in valve vaults as indicated.

3.1.6 Installation of Valve Vaults

Install valve vaults as indicated.

3.1.7 Thrust Restraint

Provide plugs, caps, tees and bends deflecting 11-1/4 degrees or more, either vertically or horizontally, with thrust restraint. Securely anchor valves or provide with thrust restraints to prevent movement. Install thrust restraints made from either thrust blocks or, for ductile-iron pipes, restrained joints.

3.1.7.1 Thrust Blocks

Provide concrete thrust blocking of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than [2000 psi](#) after 28 days. Place blocking between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, place the base and thrust bearing sides of thrust blocks directly against undisturbed earth. Place the side of thrust blocks not subject to thrust against forms, if applicable. Provide the area of bearing as shown or as directed. Place blocking so that the fitting joints are accessible for repair. Use steel rods and clamps, protected by galvanizing or by coating

with bituminous paint, to anchor vertical down bends into gravity thrust blocks.

3.1.7.2 Restrained Joints

For ductile iron pipe, design restrained joints in accordance with [DIPRA TRD](#).

3.1.8 Grout

Provide grout mix for exterior joint protection on concrete pipes of 1 part portland cement, 2 parts sand, and of sufficient liquid consistency to flow into the joint recess beneath the diaper. Provide grout mix for interior joint protection of 1 part portland cement and 1 part sand. Substitute a polyurethane foam loop, impregnated with portland cement, in lieu of grout for exterior joints, if directed.

3.1.9 Bonded Joints

Where indicated, provide a thermally welded metallic bond at each joint, including joints made with flexible couplings or rubber gaskets, of ferrous-metallic piping to effect continuous conductivity.

3.2 FIELD QUALITY CONTROL

Perform both a pressure test and a leakage test on all pipelines. Obtain the Contracting Officer's approval of the method proposed for [disposal of waste water](#) from hydrostatic tests. The Contractor is responsible for all testing. Contractor will coordinate all tests to ensure they are witnessed by the Contracting Officer. Notify the Contracting Officer at least 7 days in advance of equipment tests. Submit the [final test report](#) to the Contracting Officer within 30 days after the test.

3.2.1 Pressure Test

After installing the pipe, joints, and thrust blocks, wait at least five days before pressure testing. For the pressure test, partially backfill the trench but leave the joints exposed for examination, then fill the pipe with water to expel all air. Subject the pipeline to a test pressure of [100 psi](#) or 150 percent of the working pressure, whichever is greater, for a period of at least one hour. Open and close each valve several times during the test. Examine the exposed pipe, joints, fitting, and valves for leaks. Stop visible leaks or replace defective pipe, fittings, joints, or valves.

3.2.2 Leakage Test

Conduct the leakage test subsequent to or concurrently with the pressure test. Place the amount of water permitted as leakage for the line in a sealed container attached to the supply side of the test pump. Apply no other source of supply to the pump or line under test. Pump the water into the line by the test pump as required to maintain the specified test pressure as described for a 2 hour period. The test will be considered a failure upon exhaustion of the supply or the inability to maintain the required pressure. Determine allowable leakage by the following I-P formula:

$L = NDP/K$ Where:

L = Allowable leakage in gallons per hour.

N = Number of joints in length of pipeline tested.

D = Nominal diameter of the pipe in inches.

P = Square root of the test pressure in psig.

K = 7400 for pipe materials.

At the conclusion of the test, measure the amount of water remaining in the container and record the results in the test report.

Test ductile iron pressure lines in accordance with the requirements of AWWA C600.

3.2.3 Retesting

If any deficiencies are revealed during any test, correct such deficiencies and repeat the tests until the results of the tests are within specified allowances, without additional cost to the Government.

-- End of Section --

SECTION 33 40 00

STORMWATER UTILITIES

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges
AASHTO M 190	(2004; R 2019) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 243	(1996; R 2021) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A807/A807M	(2019) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM B26/B26M	(2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings
ASTM C32	(2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C55	(2023) Standard Specification for Concrete Building Brick
ASTM C62	(2023) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C76	(2022a) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

ASTM C76M	(2022a) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C139	(2022) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C231/C231M	(2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C270	(2019a; E 2019) Standard Specification for Mortar for Unit Masonry
ASTM C443	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C478/C478M	(2022) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C507	(2022) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C507M	(2022) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C828	(2023) Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C923/C923M	(2020) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM C1103	(2022) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

ASTM C1103M	(2019) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C1433	(2020) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM C1433M	(2022) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric)
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F1417	(2011a; E 2020) Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air
ASTM F2620	(2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Leakage Test; G, R0

SD-07 Certificates

Hydrostatic Test on Watertight Joints; G, R0

Frame and Cover or Gratings; G, R0

SD-08 Manufacturer's Instructions

Placing Pipe and Box Culvert; G, R0

SD-11 Closeout Submittals

Post-Installation Inspection Report; G, R0

LID Verification Report; G, R0

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Inspect materials delivered to site for damage and unload and store materials with minimal handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings free of dirt and debris. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe in accordance with the manufacturer's recommendations and discard if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

1.3.2 Handling

Handle materials in a manner that ensures delivery to the trench in sound, undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe sizes for culverts and storm drains are indicated on the drawings.

2.1.1 Concrete Pipe

2.1.1.1 Reinforced Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C76M ASTM C76, Class III.

2.1.1.2 Reinforced Elliptical Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C507M ASTM C507, Class HE-II standard or HE-IV where indicated for horizontal elliptical pipe.

2.1.2 Poly Vinyl Chloride (PVC) Pipe

2.1.2.1 Type PSM PVC Pipe

ASTM D3034, maximum SDR 35.

2.2 PIPE JOINTS

Provide joints that have been tested for and meet the requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

2.2.1 Concrete Pipe

2.2.1.1 Rubber Gasket Joints

Provide rubber gasket joints of a design and physical requirements conforming to ASTM C443.

2.2.1.2 Preformed Flexible Sealant Joints

Provide joints made with preformed flexible joint sealant conforming to ASTM C990.

2.2.2 Smooth Wall PE Plastic Pipe

Join pipe using butt fusion method conforming to ASTM F2620. No offset in alignment between adjacent pipe ends is permitted.

2.3 PRECAST REINFORCED CONCRETE BOX CULVERT

Manufacture precast reinforced concrete box culverts in accordance with and conforming to ASTM C1433M ASTM C1433.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Concrete

Unless otherwise specified, provide concrete and reinforced concrete conforming to the requirements for 3,500 psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide air content by volume of concrete mixture, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Determine air content in accordance with ASTM C231/C231M. Provide a minimum concrete covering over steel reinforcing of not less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. For concrete deposited directly against the ground, provide a covering thickness of at least 3 inches between steel and ground. Provide expansion-joint filler material conforming to ASTM D1751, or ASTM D1752, or provide be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.4.2 Mortar

Mortar is not allowed for pipe joints. Provide mortar for pipe connections to drainage structures and brick or block construction conforming to ASTM C270, Type M, except that the maximum placement time will be 1 hour. Provide a sufficient quantity of water in the mixture to

produce a stiff workable mortar but in no case may the quantity exceed 5 gallons of water per sack of cement. Use water that is clean and free of harmful acids, alkalis, and organic impurities. Use the mortar within 30 minutes after the ingredients are mixed with water.

2.4.3 Precast Concrete Segmental Blocks

Provide precast concrete segmental block conforming to ASTM C139, not more than 8 inches thick, not less than 8 inches long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.4.4 Brick

Provide brick conforming to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Provide mortar for jointing and plastering consisting of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. Provide joints that are completely filled and that are smooth and free from surplus mortar on the inside of the structure. Plaster brick structures with 1/2 inch of mortar over the entire outside surface of the walls. Lay brick in stretcher courses with a header course every sixth course for square or rectangular structures. Lay brick radially with every sixth course a stretcher course for round structures.

2.4.5 Precast Reinforced Concrete Manholes

Provide precast reinforced concrete manholes conforming to ASTM C478/C478M . Provide joints between precast concrete risers and tops that are full-bedded in cement mortar and smoothed to a uniform surface on both interior and exterior of the structure or made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph PIPE JOINTS.

2.4.6 Frame and Cover or Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load indicated on the drawings. Provide frame and cover or gratings made of cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.0-T6. Stamp or cast the word "Storm Sewer" into covers so that it is plainly visible.

2.4.7 Resilient Connectors

Provide flexible, watertight connectors conforming to ASTM C923/C923M for connecting pipe to manholes and inlets.

2.4.8 Flared End Sections

2.4.8.1 Concrete Flared End Sections

Provide sections of a standard design fabricated with reinforced concrete.

2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

2.5.1 Hydrostatic Test on Watertight Joints

Perform a hydrostatic test on the watertight joint types as proposed. This test will be conducted at the plant or by an independent laboratory. Only one sample joint of each type needs testing; however, if the sample

joint fails because of faulty design or workmanship, an additional sample joint may be tested.

2.5.1.1 Concrete and PE Pipe

Provide joints in reinforced concrete pipe meeting the performance requirements in ASTM C990M ASTM C990 or ASTM C443M ASTM C443. Provide joints in PE plastic pipe meeting the test requirements in ASTM D3212.

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, BOX CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavate trenches, excavate for appurtenances and backfill for culverts and storm drains, in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

3.1.1 Trenching

Excavate trenches to the width indicated on the drawings or as specified herein. Trench width should permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Place sheeting and bracing, where required, within the trench width as specified, without any overexcavation.

3.1.2 Removal of Rock

Replace rock in either ledge or boulder formation with suitable materials to provide a compacted earth cushion. Provide a compacted earth cushion between unremoved rock and the pipe with a thickness of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Maintain the cushion under the bell as well as under the straight portion of the pipe where bell-and-spigot pipe is used. Provide a compacted earth cushion between unremoved rock and the box culvert of at least 8 inches in thickness for concrete box culverts. Excavate rock as specified and defined in Section 31 00 00 EARTHWORK.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe or box culvert, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, remove such material to the depth required and replace with select granular material to the proper grade. Compact select granular material as specified in paragraph FINAL BACKFILL. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, perform such removal and replacement at no additional cost to the Government.

3.2 BEDDING AND INITIAL BACKFILL

Provide a firm bedding foundation of uniform density throughout the entire length of the pipe or box culvert.

3.2.1 Concrete Pipe

Use select granular material conforming to Section 31 00 00 EARTHWORK for

haunch and bedding material. Compact haunch and outer bedding to at least 90 percent laboratory maximum density and place in layers not exceeding 6 inch loose thickness for compaction by hand-operated compactors and 200 mm 8 inches for other than hand-operated machines. Loosely place middle bedding and do not compact. After the pipe has been properly bedded, place haunch material, at a moisture content that will facilitate compaction, evenly along both sides of the pipe and thoroughly compact each layer with mechanical tampers or rammers to the springline of the pipe. Thoroughly compact the haunch material under the haunches of the pipe. For bell and spigot pipe, form a depression in bedding material for bells so entire barrel of pipe is uniformly supported. Minimize the length, depth, and width of bell depressions to that required for properly making the particular type of joint.

3.2.1.1 Trenches

After the pipe has been properly bedded and haunch material placed to the midpoint (springline) of the pipe, backfill and compact the remainder of the trench by spreading and rolling or compacting by mechanical rammers or tampers in layers not exceeding 6 inches. Test for density as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Leave untreated sheeting in place beneath structures or pavements.

3.2.1.2 Fill Sections

For pipe placed in fill sections, uniformly spread fill material longitudinally on both sides of the pipe in layers not exceeding 6 inches in compacted depth, and compact by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe must extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, place and thoroughly compact the remainder of the fill in layers not exceeding 8 inches.

3.2.2 Plastic Pipe

Provide bedding for PVC, PE, SRPE and PP pipe meeting the requirements of ASTM D2321. Use Class IB or II material for PVC, PE, SRPE pipe bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.3 PLACING PIPE AND BOX CULVERT

Submit printed copies of the pipe or box culvert manufacturer's recommended pipe or box culvert installation procedures prior to installation. Thoroughly examine each section of pipe or box culvert before being laid; do not use defective or damaged pipe. Protect plastic pipe, excluding SRPE pipe, from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Lay pipelines to the grades and alignment indicated. Provide proper facilities for lowering sections of pipe into trenches. Do not lay pipe in water or when trench conditions or weather are unsuitable for such work. Divert drainage or dewater trenches during construction as necessary. Deflection of installed

flexible pipe must not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Plastic (PVC, HDPE, SRPE, and PP)	5

3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron Pipe

Lay pipe proceeding upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

Place pipe so that the manufacturer's reference lines, designating the top of the pipe, are within 5 degrees of a vertical plane through the longitudinal axis of the pipe. Prevent damage to or misalignment of the pipe during backfilling operations.

3.3.3 PE, SRPE, and Dual Wall and Triple Wall PP Pipe

Lay on a bed shaped to line and grade and joint sections together in accordance with manufacturer's guidelines.

3.3.4 Corrugated Steel and Aluminum Pipe and Pipe Arch

Lay pipe with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Install part paved pipe so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Provide fully paved steel pipe or pipe arch with the sheet thickness of the pipe or pipe arch painted or otherwise indicated on a label applied on the inside of the pipe or pipe arch. Coat any unprotected metal in the joints with bituminous material as specified in AASHTO M 190 or AASHTO M 243. Protect interior coating against damage from insertion or removal of struts or tie wires. Use lifting lugs to facilitate moving pipe without damage to exterior or interior coatings. Handle pipe or pipe arch and coupling bands during transportation and installation with care to preclude damage to the coating, paving or lining. Repair damaged coatings, pavings and linings in accordance with the manufacturer's recommendations prior to placing backfill. Remove and replace pipe on with coating, paving or lining that has been damaged to such an extent that satisfactory field repairs cannot be made. Accomplish vertical elongation, where indicated, in the factory. Provide suitable markings or properly placed lifting lugs to ensure placement of factory elongated pipe in a vertical plane.

3.3.5 Structural-Plate Steel

Install structural plate in accordance with **ASTM A807/A807M**. Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are tightened to meet the torque requirements of **200 foot-pounds** plus or minus **50 foot-pounds**. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Check and adjust power wrenches frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

3.3.6 Structural-Plate Aluminum

Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are torqued to a minimum of **100 foot-pounds** on aluminum alloy bolts and a minimum of **150 foot-pounds** on galvanized steel bolts. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Check and adjust power wrenches as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.

3.3.7 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe must be at least half the nominal pipe diameter or **3 feet** apart, whichever is less.

3.3.8 Precast Reinforced Concrete Box Culvert

Proceed upgrade with laying of sections and point tongue ends of tongue-and-groove box culvert section in the direction of flow.

3.4 JOINTING

3.4.1 Concrete Clay Pipe

3.4.1.1 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe and Box Culverts

Follow the recommendation of the particular manufacturer in regard to sealing compound special installation requirements. When lubricants, primers, or adhesives are used, only apply on surfaces that are dry and clean. Affix sealing compounds to the pipe or box culvert not more than 3 hours prior to installation of the pipe or box culvert. Protect sealing compounds from the sun, blowing dust, and other deleterious agents at all times. Inspect sealing compounds before installation of the pipe or box culvert, and remove and replace any loose or improperly affixed sealing compound. Align the pipe or box culvert with the previously installed pipe or box culvert, and pull the joint together.

3.4.1.2 Flexible Watertight Joints

Use lubricants, cements, adhesives, and other special installation

requirements for gaskets and jointing materials as recommended by the manufacturer. When lubricants, cements, or adhesives are used, only apply on surfaces that are clean and dry. Affix gaskets and jointing materials to the pipe not more than 24 hours prior to the installation of the pipe, and protect from the sun, blowing dust, and other deleterious agents at all times. Inspect gaskets and jointing materials before installing the pipe; remove and replace any loose or improperly affixed gaskets and jointing materials. Align the pipe with the previously installed pipe, and push the joint home. If the gasket becomes visibly dislocated when joining sections of pipe, remove the pipe and remake the joint.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construct manholes of precast reinforced concrete. Construct inlets of precast reinforced concrete. Provide manholes and inlets complete with frames and covers or grating **embedded polypropylene coated steel steps on storm structures deeper than 4 feet. The wall along the line where steps are installed must be vertical for its entire length. Adequately anchor steps to the wall with 1 foot vertical separation between steps, and install to provide at least 6 inches of space between the wall and the rungs. Make pipe connections to concrete manholes and inlets with flexible, watertight connectors.**

3.6 FINAL BACKFILL

Backfill trenches with satisfactory material deposited in layers of a maximum of **8 inches** loose thickness and compacted to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesionless soils in accordance with Section **31 00 00** EARTHWORK. Testing is the responsibility of the Contractor and will be performed at no additional cost to the Government. Unless otherwise specified, determine field in-place density of final backfill at a frequency of one test per **50 linear feet**, or fraction thereof, of each lift of backfill. Submit test results in accordance with Section **31 00 00** EARTHWORK. Do not displace or damage pipe or box when compacting final backfill by rolling or operating heavy equipment parallel with the pipe or box. Movement of construction machinery over a culvert or storm drain at any stage of construction will be at the Contractor's risk. Repair or replace any damaged pipe. Protect concrete pipes with a minimum of **3 feet** of cover prior to permitting heavy construction equipment to pass over them during construction. Provide the minimum cover for construction loads over corrugated steel pipes as specified in Section 26, Division II of **AASHTO HB-17**. Provide minimum cover for construction loads over plastic pipes as specified in **ASTM D2321**.

3.7 FIELD QUALITY CONTROL

3.7.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

3.7.1.1 Leakage Test

Test pipe lines for leakage prior to completing backfill by performing either an exfiltration test, low pressure air pipeline test or by

individual pipe joint testing. Submit leakage test results to the Contracting Officer.

3.7.1.1.1 Exfiltration Test

Prior to exfiltration tests, backfill the trench up to at least the lower half of the pipe. If required, place sufficient additional backfill to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. When the water table is **2 feet** or more above the top of the pipe at the upper end of the pipeline section to be tested, measure infiltration using a suitable weir or other device acceptable to the Contracting Officer. Perform exfiltration test by filling the line to be tested with water so that a head of at least **2 feet** is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. Allow the filled line to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, reestablish the head. Measure the amount of water required to maintain this water level during a 2-hour test period. Leakage as measured by the exfiltration test must not exceed **0.2 gallons per inch in diameter per 100 feet** of pipeline per hour. Correct visible leaks encountered regardless of leakage test results.

3.7.1.1.2 Low Pressure Air Pipeline Tests

Perform low pressure air testing for vitrified clay pipes in accordance with **ASTM C828**. Perform low pressure air testing for plastic pipe in accordance with **ASTM F1417**. Perform low pressure air testing procedures for other pipe materials using the pressures and testing times prescribed in **ASTM C828**, after consultation with the pipe manufacturer.

3.7.1.1.3 Individual Pipe Joint Testing

Testing of individual joints for leakage by low pressure air or water must conform to **ASTM C1103M** **ASTM C1103**.

3.7.1.2 Deflection Testing

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads must not exceed the limits in paragraph PLACING PIPE AND BOX CULVERT above as percent of the average inside diameter of pipe. Use a laser profiler or mandrel to determine if allowable deflection has been exceeded.

3.7.1.2.1 Laser Profiler

Inspect pipe interior with laser profiling equipment. Utilize low barrel distortion video equipment.

3.7.1.2.2 Mandrel

Pass the mandrel through each run of pipe by pulling it by hand. If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, stop and begin test from the opposite direction. The mandrel must meet the pipe manufacturer's

recommendations and the following requirements. Provide a mandrel that is rigid, nonadjustable, has a minimum of 9 fins, pulling rings at each end, and is engraved with the nominal pipe size and mandrel outside diameter. The mandrel must be 5 percent less than the certified-actual pipe diameter for plastic pipe, 5 percent less than the certified-actual pipe diameter for corrugated steel and aluminum, 3 percent less than the certified-actual pipe diameter for ductile iron culvert pipe. The Government will verify the outside diameter (OD) of the Contractor provided mandrel through the use of Contractor provided proving rings.

3.7.2 Inspection

3.7.2.1 Post-Installation Inspection

Perform a CCTV inspection and video recording of pipes with diameters 48 inches or less. Visually inspect pipes with diameters larger than 48 inches. Inspect each segment of pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

3.7.2.1.1 Concrete Pipe

An engineer must evaluate all pipes with cracks with a width greater than 0.25 mm 0.01 inches, but less than 0.10 inches to determine if any remediation or repair is required.

3.7.2.1.2 Flexible Pipe

Check each flexible pipe (PE) for rips, tears, joint separations, soil migration through the joint, cracks, localized buckling, bulges, settlement and alignment.

3.7.2.1.3 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.7.2.2 Low Impact Development Inspection

Inspect Low Impact Development (LID) features indicated on the design portion of the LID Verification Report. Certify LID features were constructed according to plans and specifications or by submitting as-built drawings in accordance with UFGS 01 78 00 Closeout Submittals. When as-built drawings show deviations to the LID features, document the deviations on the LID Verification Report.

3.7.3 Repair of Defects

3.7.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

3.7.3.2 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diameter of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.7.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

3.7.3.3.1 Concrete Pipe

Replace pipes having cracks with a width greater than 0.1 inches.

3.7.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

3.8 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.9 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

-- End of Section --

SECTION 33 48 00

BIORETENTION AREAS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 43 (2005; R 2018) Standard Specification for
Sizes of Aggregate for Road and Bridge
Construction

AASHTO M 278 (2015) Standard Specification for Class
PS46 Poly(Vinyl Chloride) (PVC) Pipe

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M (2023) Standard Specification for Concrete
Aggregates

1.2 SUBMITTALS

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

SD-01 Preconstruction Submittals

Planting Soil Source; G

SD-06 Test Reports

Water; G

Planting Soil Sieve Analysis; G

Standard Soil Test; G

Organic Matter Test; G

Soluble Salts Test; G

Standard Infiltration Rate Test; G

1.3 DESCRIPTION OF WORK

Bioretention areas are small landscaped basins intended to provide water quality management by filtering stormwater runoff before release into stormdrain systems. This work consists of installing bioretention areas as specified and as shown. This work must include the necessary

materials, labor, supervision, and equipment for installation of a complete system. Coordinate this Section with Section 31 00 00 EARTHWORK, and Section 32 92 19 SEEDING.

1.4 DELIVERY, INSPECTION, STORAGE, AND HANDLING

Store the materials in designated areas, as recommended by the manufacturer, and protected from the elements, direct exposure, and damage. Do not drop containers from trucks. Material must be free of defects that would void required performance or warranty. Plants must be inspected upon arrival at the jobsite for conformity to species and quality.

PART 2 PRODUCTS

2.1 PLANTINGS

Plantings must be of the species, size, quantity, and location as shown.

2.2 WATER

Water sources of water must be of suitable quality for irrigation and approved by the Contracting Officer prior to use.

2.3 MULCHES TOPDRESSING

Shredded hardwood, free from noxious weeds, mold, and other deleterious materials. The mulch must be aged a minimum of six months.

2.4 PLANTING SOIL

The soil must be a uniform mix, free of stones, stumps, roots, and other similar objects larger than one inch. Other materials or substances that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations must not be mixed or dumped within the bioretention area. The planting soil must be free of noxious weeds.

2.4.1 Planting Soil Composition

The planting soil must be salvaged or furnished. The planting soil must contain the following components:

Sand	85 percent
Fines (silt/clay)	8 percent
Organic matter (peat moss)	3 - 5 percent

At least 45 calendar days prior to the start of construction of bioretention areas, submit the [Planting Soil Source](#) and [Planting Soil Sieve Analysis](#) for approval.

2.4.2 Criteria for Planting Soil

Test the planting soil and ensure it meets the following criteria:

pH	5.2 - 7.0
Organic Matter	3 - 5 percent
Magnesium	35 pounds per acre (lb/ac)
Phosphorus P205	75 lb/ac
Potassium K20	85 lb/ac
Soluble Salts	not to exceed 500 parts per million (ppm)
Permeability	Two inches per hour

Each bioretention area must have a minimum of one test set, submitted for approval. Each test set must consist of the [Standard Soil Test](#) for pH, phosphorus, magnesium and potassium, an [Organic Matter Test](#), a [Soluble Salts Test](#), and [Standard Infiltration Rate Test](#). All testing results must come from the same testing facility.

If the pH falls outside the acceptable range, it may be modified with lime (to raise) or iron sulfate plus sulfur (to lower). The lime or iron sulfate must be mixed uniformly into the planting soil prior to use in the bioretention area.

If the planting soil does not meet the minimum requirement for magnesium, it may be modified with magnesium sulfate. Likewise, if the planting soil does not meet the minimum requirements for potassium, it may be modified with potash. Magnesium sulfate and potash must be mixed uniformly into the planting soil prior to use in the bioretention area.

2.5 UNDERDRAIN GRAVEL

The underdrain gravel must meet the gradation requirements of [AASHTO M 43](#), No. 57 stone.

2.6 UNDERDRAIN PIPING

The underdrain piping must comply with [AASHTO M 278](#).

2.7 GEOTEXTILE FILTER FABRIC

Provide geotextile in accordance with Section [31 05 19.13](#) GEOTEXTILES FOR EARTHWORK.

2.8 SAND

Sand must comply with [ASTM C33/C33M](#). Sand substitutions such as Diabase and Graystone #10 are not acceptable. Calcium carbonated and dolomitic sand substitutions are not acceptable. Do not use "rock dust" for sand.

PART 3 EXECUTION

3.1 COMPACTION AND BACKFILLING

Compaction of the base of the bioretention area and the required backfill must be minimized to the maximum extent. When possible, use excavation

hoes to remove the original soil. If bioretention areas are excavated using a loader, use wide track or marsh track equipment or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high pressure tires will cause excessive compaction resulting in reduced infiltration rates and storage volumes and is not acceptable. Compaction will significantly contribute to design failure.

Alleviate compaction at the base of the bioretention area by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations must refracture the soil profile to a depth of **6-12 inches**. Substitute methods must be approved by the Government prior to use. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

When backfilling the bioretention area, place soil in lifts of **12 to 24 inches**. Do not use heavy equipment within the bioretention area. Heavy equipment can be used around the perimeter of the basin to supply soils and sand. Grade bioretention materials to final grade by hand or with light equipment.

3.2 UNDERDRAINS

Provide underdrains as shown. Cap the ends of underdrain pipes not terminating in a drainage structure or cleanout/well.

The underdrain pipe must be constructed at a minimum slope of 0.25 percent or as shown. Place the cleanouts/observation wells of non-perforated pipe vertically in the bioretention area as shown. Connect the cleanouts/wells to the perforated underdrain with the appropriate manufactured connections. Extend the cleanouts/wells **three inches** above the grade elevation, and cap with a screw cap. Cleanouts/observation wells must be the same diameter as the underdrain pipe served.

3.3 PLANT INSTALLATION

Mulch around individual plants only. Plant the root ball so 1/8 of the ball is above the final grade surface. Keep the root stock of the plant material moist during transport and on-site storage. The diameter of the planting pit must be at least six inches larger than the diameter of the planting ball. Set and maintain the plant straight during the entire planting process. Thoroughly water ground bed cover after installation.

3.3.1 Bracing Trees

Brace the trees using **2-inch by 2-inch** stakes as necessary and for the first growing season only. Stakes are to be equally spaced on the outside of the tree ball.

3.3.2 Fertilizer

The topsoil specifications provide enough organic material to adequately supply nutrients from natural cycling. The primary function of the bioretention area is to improve water quality. Adding fertilizers defeats, or at a minimum impedes this goal. Only add fertilizer if wood chips or mulch is used to amend the soil. Rototill urea fertilizer at a rate of **2 pounds per 1000 square feet**.

3.4 CONSTRUCTION SEQUENCE

- a. Install erosion and sediment control devices as shown.
- b. Grade site to elevations shown. Stabilize grading except for the bioretention areas.
- c. Finish paving the roadways and parking lots.
- d. Complete permanent seeding. Use a continuous sod border on the bioretention area sideslopes to facilitate soil stabilization.
- e. Remove trapped/accumulated sediments from bioretention area locations.
- f. Excavate bioretention areas to proposed invert depth and scarify the existing soil surfaces, taking care not to compact the in-situ materials.
- g. Place geotextile fabric on bottom and sides of bioretention area with a 6- to 12-inch overlap. Place #57 stone layer and install underdrains and cleanouts as shown. Place geotextile fabric atop stone layer.
- h. Backfill bioretention areas with planting soil as shown and as specified. Overfilling is recommended to account for settlement.
- i. Presoak the planting soil prior to planting vegetation to allow for settlement. This can be done by water truck or allowing water to enter the pit from a rain event.
- j. Excavate or fill to achieve proper design grade, leaving space for the upper layer of surface cover, (i.e. river gravel, mulch, and/or topsoil that will bring the surface to final grade and ready for planting.
- k. Plant vegetation specified in the landscape plan for bioretention area.
- l. Mulch and install erosion protection at entrance points. Remove erosion and sediment control devices after the site is stabilized, and in accordance with the Stormwater Pollution Prevention Plan.

-- End of Section --

SECTION 33 51 15

NATURAL-GAS DISTRIBUTION PIPELINES

PART 1 GENERAL

1.1 SUMMARY

The gas distribution pipeline includes piping that conveys natural gas and all appurtenances from point of connection with existing system, to a point approximately 5 feet from the facility being served. The distribution pipeline, which must comply with 49 CFR 192, terminates at the isolation valve, service pressure regulator, or meter, whichever is the most downstream component before serving the facility gas piping. The facility gas piping that connects to this termination point is specified in Section 23 11 20 FACILITY GAS PIPING and must comply with NFPA 54.

Section 31 11 00 CLEARING AND GRUBBING, applies to this section unless otherwise specified.

1.2 REFERENCES

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

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1	(2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.4	(2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1½ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN PETROLEUM INSTITUTE (API)

API RP 686	(2009) Recommended Practice for Machinery Installation and Installation Design
API Spec 5L	(2018; 46th Ed; ERTA 2018) Line Pipe
API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves
API Std 1104	(2013; Errata 1-3 2014; Addendum 1 2014; Errata 4 2015; Addendum 2 2016) Welding of

Pipeline and Related Facilities

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.5 (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9 (2018) Factory-Made Wrought Buttwelding Fittings

ASME B16.11 (2022) Forged Fittings, Socket-Welding and Threaded

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

ASME B16.25 (2022) Buttwelding Ends

ASME B31.8 (2022; Supplement 2022) Gas Transmission and Distribution Piping Systems

ASME BPVC SEC IX (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

ASME BPVC SEC VIII D1 (2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASME PTC 25 (2023) Pressure Relief Devices

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M (2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A106/A106M (2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A181/A181M (2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

ASTM A333/A333M (2016) Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness

ASTM D2513 (2018a) Standard Specification for

	Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM F1055	(2016; R 2022a) Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX)Pipe and Tubing
ASTM F1802	(2022) Standard Test Method for Performance Testing of Excess Flow Valves
ASTM F1948	(2015) Standard Specification for Metallic Fittings for Use on Outside Diameter Controlled Thermoplastic Gas Distribution Pipe and Tubing
ASTM F1973	(2013; R 2018) Standard Specification for Factory Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide 11 (PA11) and Polyamide 12 (PA12) Fuel Gas Distribution Systems
ASTM F2138	(2012; R 2017) Standard Specification for Excess Flow Valves for Natural Gas Service
ASTM F2164	(2018) Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
ASTM F2620	(2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
ASTM F2786	(2010) Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Gaseous Media Under Pressure (Pneumatic Leak Testing)

ASTM F2897 (2015a) Standard Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)

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

MSS SP-25 (2018) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-142 (2012) Excess Flow Valves for Fuel Gas Service, NPS 1 1/2 through 12

MASTER PAINTERS INSTITUTE (MPI)

MPI 9 (2016) Alkyd, Exterior Gloss (MPI Gloss Level 6)

NACE INTERNATIONAL (NACE)

NACE SP0169 (2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NACE SP0185 (2024) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE SP0274 (1974; R 2011) High Voltage Electrical Inspection of Pipeline Coatings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54 (2024) National Fuel Gas Code

NFPA 58 (2024; TIA 23-1) Liquefied Petroleum Gas Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4 (2007) Brush-Off Blast Cleaning

SSPC Paint 25 (1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

SSPC SP 1 (2015) Solvent Cleaning

SSPC SP 3 (2018) Power Tool Cleaning

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192 Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

49 CFR 192.105

Design Formula for Steel Pipe

49 CFR 192.197

Control of the Pressure of Gas Delivered
from High-Pressure Distribution Systems

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pipe, Fittings, and Associated Materials

SD-03 Product Data

Materials and Equipment;

Spare Parts;

Pipe and Accessory Coatings;

SD-05 Design Data

Connections to Existing Lines; G, R0

SD-06 Test Reports

Pressure and Leak Tests

SD-07 Certificates

Welder's training and qualifications

Jointing of Plastic Piping

SD-08 Manufacturer's Instructions

EFV Design and Installation Guide

SD-10 Operation and Maintenance Data

Gas Distribution System and Equipment Operation;

Gas Distribution System Maintenance;

Gas Distribution Equipment Maintenance;

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 Welding General

- a. Qualification of welding procedures and Welder's training and

qualifications, including equipment used, detailed explanation of the procedure, and successfully making joints which pass tests must comply with Subpart E of 49 CFR 192.

- b. Submit procedures for welding of metallic piping that comply with API Std 1104 section 5, 12, or App. A; or ASME BPVC SEC IX. Quality of test welds used to qualify a procedure must be determined by destructive test. Submit the results of destructive testing of each procedure qualification for Government record.
- c. Submit a certificate of Welder's training and qualifications by test, requalification, or production work testing in conformance with API Std 1104 section 6, 12, or App. A; ASME BPVC SEC IX; or as allowed per 49 CFR 192 Appendix C.
- d. Submit a list of names and identification symbols for all qualified welders and welding operators to be used on the project.
- e. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.4.1.2 Jointing of Plastic Piping

- a. Join piping by performance qualified plastic pipe joiners, qualified by a person who has been trained and certified by the manufacturer of the pipe, using manufacturer's pre-qualified joining procedures that have been tested in accordance with 49 CFR 192 Subpart F. Inspect joints by an inspector qualified in the joining procedures being used.
- b. Submit manufacturer's pre-qualified joining procedures and the results of testing performed to 49 CFR 192 Section 283.
- c. Plastic pipe joiners must be re-qualified at the beginning of each project by making specimen joints using the approve procedures and having those joints inspected by a qualified inspector and tested in accordance with 49 CFR 192 Section 285.
- d. Submit a certificate of qualified jointing procedures, training procedures, qualifications of trainer, and training test results for joiners and inspectors. Notify the Contracting Officer at least 24 hours in advance of the date to qualify joiners and inspectors.

1.4.2 Pre-Installation Conference

1.4.2.1 Shop Drawings

Submit shop drawings, within 30 days of contract award, containing complete schematic and piping diagrams and any other details required to demonstrate that the system has been coordinated and functions properly as a unit. Show on the drawings proposed layout and anchorage of the system and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4.2.2 Connecting and Abandonment Plan

Submit written notification of the method and schedule for making connections to existing gas lines, to the Contracting Officer at least 10 days in advance. Include gas line tie in, hot taps, abandonment/removal or demolition, purging, and plugging as applicable. ASME B31.8 may be

used to help develop these plans, but the connection and abandonment must comply with 49 CFR 192. Include in submittal connections to existing lines.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to the site for damage, and store with a minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.2 Handling

Handle pipe and components carefully to ensure a sound, undamaged condition. Take particular care not to damage pipe coating. Repair damaged coatings to original finish. Do not place pipe or material of any kind inside another pipe or fitting after the coating has been applied, except as specified in paragraph INSTALLATION. Handle coated steel piping in accordance with its listing and the manufacturer's written procedures. Handle plastic pipe in conformance with AGA XR0603.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of equipment and material specified, after approval of the detail shop drawings and not later than 2 months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 PIPE, FITTINGS, AND ASSOCIATED MATERIALS

Provide only materials that are allowed for natural gas by 49 CFR 192 for the specified distribution pipeline being installed.

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Provide written verification and point of contact for a supporting service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Mark all valves, flanges, and fittings in accordance with MSS SP-25. Submit a complete list of materials and equipment, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions, including, but not limited to the following:

- a. Electrical Isolation Devices and Isolating Flange Kits.
- b. Fittings
- c. Piping
- d. Pipe and Accessory coatings
- e. Pressure Reducing Valves.
- f. Meters
- g. Regulators.
- h. Shut-off Valves

i. Excess Flow Valve

2.1.1.1 Steel Pipe for Natural Gas Distribution

Provide steel piping that complies with [API Spec 5L](#), Grade B, or X42; [ASTM A53/A53M](#), Grade A or B; [ASTM A106/A106M](#), Grade A, B or C; [ASTM A333/A333M](#), Grade 1 or 3. Determine minimum pipe wall thickness as specified in [49 CFR 192.105](#) section "Design Formula for Steel Pipe" for the specific design conditions. Pipe wall thickness less than schedule 80 for pipes less than 2.5 inches diameter is not permitted.

2.1.1.2 Corrosion Protection for Steel Pipe for Underground Installation

2.1.1.2.1 External Coating Systems

Where steel pipe installation below ground is required by design of the gas carrier pipe, or as encasement for plastic pipe, provide pipe with a factory applied polyolefin resin coating system conforming to [NACE SP0185](#), Type A. Pipe exterior must be cleaned to a commercial grade blast cleaning finish in accordance with [SSPC SP 6/NACE No.3](#). Apply adhesive compound to the pipe with a nominal thickness of [10 mils](#) (plus or minus 10 percent). Immediately after the adhesive is applied, extrude a seamless tube of polyolefin over the adhesive to produce a bonded seamless coating, with a nominal thickness of [40 mils](#) (plus or minus 10 percent) of polyolefin resin for pipes up to [16 inches](#) in diameter. For pipes [18 inches](#) and larger in diameter, apply a minimum thickness of 60 mils (plus or minus 10 percent) polyolefin resin.

Do not coat pipe and fittings for aboveground lines.

2.1.1.2.2 Cathodic Protection Systems

Provide cathodic protection system in accordance with [NACE SP0169](#) and the applicable UFGS DIV 26 specification for the designed type of cathodic protection.

2.1.1.3 Steel and Malleable Iron Fittings, [1-1/2 inches](#) and Smaller

Provide steel butt-weld fittings conforming to [ASME B16.9](#) or threaded malleable iron fittings for natural gas pipe conforming to [ASME B16.11](#).

2.1.1.4 Steel Fittings, [2 inches](#) and Larger

Provide weld neck pipe flanges and flanged fittings, including bolts, nuts, and bolt patterns in accordance with [ASME B16.5](#), Class 150. Provide butt-weld fittings in accordance with [ASME B16.9](#).

2.1.1.5 Steel Forged Branch Connections

Provide steel forged branch connections conforming to [ASTM A181/A181M](#), Class 60, carbon steel.

2.1.1.6 Flange Gaskets

Provide gaskets for natural gas systems that are non-asbestos compressed material gaskets in accordance with [ASME B16.21](#), [1/16 inch](#) minimum thickness, full face or self-centering flat ring type, containing aramid fibers bonded with nitrile butadiene rubber (NBR), or glass fibers bonded with polytetrafluoroethylene, suitable for maximum [600 degrees F](#) service.

2.1.7 Pipe Threads

Provide pipe threads for natural gas piping conforming to ASME B1.20.1.

2.1.8 Sealants for Steel Pipe Threaded Joints in Natural Gas Systems

2.1.8.1 Sealing Compound

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE, Class 20 or less that is qualified for use with natural gas.

2.1.8.2 Tape

Provide polytetrafluoroethylene tape conforming to ASTM D3308 that is qualified for use with natural gas.

2.2 PLASTIC PIPE, TUBING, FITTINGS AND JOINTS

2.2.1 Polyethylene Gas Pressure Pipe, Tubing, and Fittings

Provide polyethylene (PE) pipe, tubing, fittings conforming to ASTM D2513, as specified in 49 CFR 192 Appendix B and manufactured using material that complies with ASTM D3350. Pipe wall thickness must comply with the Standard Dimension Ratio, SDR-11, or lower value, meaning thicker wall. The Hydrostatic Design Basis (HDB) of the selected PE material must exceed the Maximum Allowable Operating Pressure (MAOP), at the anticipated operating temperature of the system in which it is installed. Mark pipe, tubing, and fittings as required by ASTM D2513 and with traceability code per ASTM F2897.

Provide polyethylene fittings that are constructed of polyethylene of the same material classification and SDR as the connecting pipe, and comply with ASTM D2513. Provide fittings with butt-type fusion fittings complying with ASTM D3261 and socket-type fusion fittings complying with ASTM D2683.

Where mechanical fittings are specified on the engineering drawings, provide mechanical fittings that comply with ASTM F1948 and are category 1 for pressure integrity, gas tightness, and provide pull-out resistance equivalent to the pipe strength.

Provide heat fusion joints complying with ASTM F2620 and the manufacturer's written procedure approved by the contracting officer. Electro fusion joints fittings must comply with ASTM F1055 and the manufacturer's written procedure approved by the contracting officer. Perform underground installations in conformance with ASTM D2774.

2.3 VALVES

2.3.1 Carbon Steel Valves for Natural Gas Pipelines

Provide valves suitable for shutoff or isolation in natural gas pipelines conforming to the requirements of 49 CFR 192. All materials used in valve construction must be resistant to the action of the gas being distributed under the service conditions.

Provide carbon steel valves installed in natural gas pipelines that comply with API Spec 6D. Provide ball, check, gate, and plug valves as specified

in the design drawings.

Provide Class 150 steel valves 1-1/2 inches and smaller installed underground with butt-weld ends complying with ASME B16.25, with square wrench operator adaptor and corrosion prevention.

Provide Class 150 steel valves 1-1/2 inches and smaller installed aboveground with butt-weld complying with ASME B16.25 or threaded ends complying with ASME B1.20.1, with hand wheel or wrench operator.

Provide Class 150 steel valves 2 inches and larger installed underground with butt-weld ends complying with ASME B16.25, and square wrench operator adaptor and corrosion prevention coating.

Provide Class 150 steel valves 2 inches and larger installed aboveground with butt-weld complying with ASME B16.25 or flanged ends complying with ASME B16.5, with hand wheel or wrench operator.

Provide valves 8 inches and larger with worm or spur gear operators, totally enclosed, grease packed, and sealed, with operators having Open and Closed stops and position indicators. Provide locking feature where indicated. Wherever the lubricant connections are not conveniently accessible, provide extensions for the application of lubricant. Provide valves with lubricant compatible with gas service.

2.3.2 Excess Flow Valve (EFV)

Provide bypass type EFV with automatic reset that conforms to MSS SP-142 and ASTM F2138 and tested to ASTM F1802. Submit an EFV Design and Installation Guide which includes the manufacturer's product design data and installation instructions. Submit all traceability information for each EFV to include, but not limited to, the manufacturer, part number, serial number, and geographic information system coordinates of the installed location. Provide appropriate valve box where access for maintenance or reset is required.

2.3.3 Valve Box

Provide street valve box with cast-iron cover and two-piece 5-1/4 inch shaft-slip valve box extension. Cast the word "Gas" into the box cover. Use valve box for areas as follows:

- a. Roads and Traffic Areas: Heavy duty, cast iron cover.
- b. Other Areas: Standard duty, concrete cover.

2.4 PRESSURE REGULATORS

Provide ferrous bodied regulators with backflow protection, designed to meet the pressure, temperature, flow and other service conditions.

2.4.1 Natural Gas Main Regulators

Provide pressure regulators for main gas distribution pipelines from a qualified manufacture of pipeline regulators. Equip distribution pipelines with regulators where that pipeline is supplied from a source of gas that is at higher pressure than the maximum allowable operating pressure of the distribution pipeline. Provide regulators of adequate capacity that are rated for the inlet pressure of the gas source and the

anticipated operating temperature. In addition to the pressure regulating devices, provide a protective method to prevent overpressuring of the system in accordance with 49 CFR 192, Section 195. Suitable protective devices are as follows:

- a. Spring-loaded relief valve meeting the provisions of ASME BPVC SEC VIII D1.
- b. Pilot-loaded back pressure regulator used as relief valve, so designed that failure of the pilot system causes the regulator to open.
- c. Weight-loaded relief valves conforming to ASME PTC 25.
- d. Monitoring relief valves conforming to ASME PTC 25.
- e. Series regulator installed upstream from the primary regulator, set to limit the pressure on the inlet of the primary regulator continuously to the maximum allowable operating pressure of the system, or less.
- f. Automatic shutoff device installed in series with the primary regulator, set to shut off when the pressure on the distribution system reaches the maximum allowable operating pressure of the system, or less, which remains closed until manually reset.
- g. Spring-loaded, diaphragm type relief valves.

2.4.2 Natural Gas Service Regulators

Provide ferrous bodied service regulators conforming to AGA ANSI B109.4 with downstream pressure relief valve where distribution pipeline pressure does not exceed 125 psig.

Service regulators must meet each of the following requirements.

- a. Capable of reducing distribution line pressure to the safe pressure required by the connected equipment.
- b. Capable of limiting, under no flow conditions, the build-up of downstream pressure that would cause unsafe operation of the connected equipment.
- c. Pipe connections of 2 inches or less.
- d. Single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas pressure at the regulator inlet.
- e. Valve seat of resilient materials designed to withstand flow conditions when pressed against the valve port.
- f. Self-contained with no external static or control lines.

Set pressure relief at a lower pressure than would cause unsafe operation of any connected and properly adjusted gas utilization equipment.

2.5 METERS

Provide gas meters for natural gas that comply with AGA ANSI B109.2, pedestal mounted, diaphragm style, enamel-coated steel case. Provide diaphragm-type meter conforming to AGA ANSI B109.1 for required flow rates

less than 500 cfh, or [AGA ANSI B109.2](#), for flow rates 500 cfh and above as required by local gas utility supplier. Provide combined register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Provide temperature-compensated type meters sized for the required volumetric flow rate and suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with over-pressure protection as specified in [49 CFR 192](#) and [ASME B31.8](#). Provide meters that are tamper-proof seismic protection. Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per [100 cubic feet](#) of gas. Minimum service life must be 30,000,000 cycles.

2.5.1 Utility Monitoring and Control System (UMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS for data gathering in units of [cubic feet](#). Provide meters that do not require power to function and deliver data. Output signal must be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor. Meters installed must comply with Section [25 05 11.23 CYBERSECURITY FOR HVAC CONTROL SYSTEMS](#).

2.5.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e. electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter must be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

2.6 TELEMETERING OR RECORDING GAUGES

Equip each distribution system supplied by more than one district pressure regulating station with telemetering or recording pressure gauges to indicate the gas pressure in the district line.

2.7 GAS TRANSITION FITTINGS

Provide manufactured steel-to-plastic gas transition fittings approved for jointing steel and polyethylene pipe, conforming to [ASTM F1973](#) requirements for transition fittings.

Provide anodeless riser on service lines to transition from below grade plastic piping to above grade steel piping in accordance with [49 CFR 192](#). Polyethylene-to-steel anodeless risers must comply with [ASTM F1973](#) and [ASTM D2513](#) - Category 1 specifications for gas tight seal and pull-out resistance. Protect steel pipe from corrosion by a factory applied coating.

2.8 IDENTIFICATION

Provide pipe flow markings and metal tags for each valve, meter, and

regulator as required by the Contracting Officer.

2.9 ELECTRICALLY ISOLATED JOINT MATERIALS

Provide insulating joint materials between flanged or threaded metallic pipe systems to electrically isolate piping that is protected by cathodic protection systems. Devices must comply with NACE requirements.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EXCAVATION AND BACKFILLING

Earthwork is as specified in Section 31 00 00 EARTHWORK.

3.3 LPG CONTAINERS

Install LPG containers in accordance with NFPA 58 requirements for the type and volumetric capacity of the designed tank. Install each container with the required appurtenances as defined in NFPA 58. Mount each LPG tank on a concrete pad with anchor bolts or other tie down devices that provide resistance to tip over, caused by external forces defined in ASCE 7-16 and allow necessary movement to compensate for thermal expansion and contraction. Observe required separation distance from occupied buildings and building openings.

3.4 GAS MAINS

Provide steel pipe for aboveground installation. Provide polyethylene pipe for underground service.

3.5 SERVICE LINES

Construct service lines of materials specified for gas mains and extend from a gas main to and including the point of delivery within 5 feet of the building. The point of delivery is the meter set assembly. Connect the service lines to the gas mains as indicated.

Where indicated, provide service line with an isolation valve of the same size as the service line, located in a valve box. Make the service lines as short and as straight as practicable between the point of delivery and the gas main, without bends or lateral curves unless necessary to avoid obstructions or otherwise permitted. Lay service lines with as few joints as practicable using standard lengths of pipe, use shorter lengths only for closures. Do not install polyethylene service lines aboveground.

3.6 WORKMANSHIP AND DEFECTS

Ensure pipe, tubing, and fittings are clear and free of cutting burrs and defects in structure or threading, and thoroughly brushed and blown free of chips and scale. Do not repair, but replace defective pipe, tubing, or fittings.

3.7 PROTECTIVE COATING

3.7.1 Protective Coating for Underground Steel Pipe

Where steel pipe is installed below grade for either the gas carrier pipe or as a casing for plastic carrier pipe, protect this pipe from corrosion by an extruded polyolefin resin coating system over a soft adhesive applied to the steel pipe. This coating must be either factory applied or applied using a field plant especially equipped for the purpose. Hand apply protective covering to valves and fittings that cannot be coated and wrapped mechanically, preferably at the plant that applies the covering to the pipe. Coat and wrap joints by hand, in a manner and with materials that produce a covering equal in thickness to that of the covering applied mechanically.

3.7.1.1 Field Plant Applied Polyolefin Resin Coating System

Provide a polyolefin resin coating system conforming to [NACE SP0185](#), Type A. Clean the exterior of the pipe to a commercial grade blast cleaning finish in accordance with [SSPC SP 6/NACE No.3](#), and apply adhesive compound to the pipe with a nominal thickness of [10 mils](#) (plus or minus 10 percent). Immediately after the adhesive is applied, extrude a seamless tube of polyolefin over the adhesive to produce a bonded seamless coating, with a nominal thickness of [40 mils](#) (plus or minus 10 percent) of polyolefin resin for pipes up to [16 inches](#) in diameter. For pipes [18 inches](#) and larger in diameter, apply a minimum thickness of [60 mils](#) (plus or minus 10 percent) polyolefin resin.

3.7.1.2 Pipe Joint and Field Repair Coating System

Apply joint coating and field repair material as recommended by the coating manufacturer, consisting of one the following:

- a. Heat shrinkable polyethylene sleeves.
- b. High density polyethylene/bituminous rubber compound tape.

Inspect the coating system for holes, voids, cracks, and other damage during installation.

3.7.1.3 Inspection of Pipe Coatings

Repair any damage to the protective covering during transit and handling before installation. After field coating and wrapping has been applied, inspect the entire pipe using an electric holiday detector with impressed current set at a value in accordance with [NACE SP0274](#) using a full-ring, spring-type coil electrode. Equip the holiday detector with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Immediately repair all holidays in the protective covering upon detection. The Contracting Officer reserves the right to inspect and determine the suitability of the detector. Furnish labor, materials, and equipment necessary for conducting the inspection.

3.7.2 Protective Covering for Aboveground Piping Systems

Apply finish painting conforming to the applicable paragraphs of Section [09 90 00](#) PAINTS AND COATINGS and as follows:

3.7.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer of the same type paint as the shop primer. Solvent-clean surfaces that have not been shop primed in accordance with [SSPC SP 1](#). Mechanically clean surfaces that contain loose rust, loose mill scale, and other foreign substances by power wire brushing in accordance with [SSPC SP 3](#) or brush-off blast clean in accordance with [SSPC 7/NACE No.4](#) and primed with ferrous metal primer in accordance with [SSPC Paint 25](#). Finish primed surfaces with two coats of exterior alkyd paint conforming to [MPI 9](#).

3.7.2.2 Nonferrous Surfaces

Do not paint nonferrous surfaces.

3.7.3 Protective Covering for Piping in Valve Boxes and Manholes

Apply protective coating to piping in valve boxes or manholes as specified for underground steel pipe.

3.8 INSTALLATION

Install gas distribution system and equipment in conformance with the manufacturer's recommendations and applicable sections of [49 CFR 192](#).

3.8.1 Installing Pipe Underground

Grade gas mains and service lines as indicated. Grade service lines so as to drain back to the main or into drips as indicated. Weld joints in steel pipe except as otherwise permitted for installation of valves. Provide mains with [24 inch](#) minimum cover; service lines with [18 inch](#) minimum cover; and place both mains and service lines on firmly compacted select material for the full length.

Where indicated, encase, bridge, or design the main to withstand any anticipated external loads as specified in [49 CFR 192](#). Provide standard weight black steel pipe encasement material with a protective coating as specified. Separate the pipe from the casing by insulating spacers and seal the ends with casing bushings. Excavate the trench below pipe grade, bed with bank sand, and compact to provide full-length bearing. Laying pipe on blocks to produce uniform grade is not permitted. Ensure that the pipe is clean inside before it is lowered into the trench and keep free of water, soil, and all other foreign matter that might damage or obstruct the operation of the valves, regulators, meters, or other equipment. When work is not in progress, securely close open ends of pipe or fittings with expandable plugs or other suitable means. Minor changes in line or gradient of pipe that can be accomplished through the natural flexibility of the pipe material without producing permanent deformation and without overstressing joints may be made when approved.

Make changes in line or gradient that exceed the limitations specified with fittings. When cathodic protection is furnished, provide electrically insulated joints or flanges.

When polyethylene piping is installed underground and not encased in a metallic casing, place a tracer wire or other electrically conductive element above the pipe in accordance with [49 CFR 192](#) to permit locating with underground detection devices. After laying of pipe and testing,

backfill the trench in accordance with Section 31 00 00 EARTHWORK, and in a manner provides firm support under the pipe and prevents damage to the pipe and pipe coating from equipment or from the backfill material.

3.8.2 Installing Pipe Aboveground

Protect aboveground piping against dirt and other foreign matter, as specified for underground piping. Weld joints in steel pipe; however, joints in pipe 1-1/2 inches in diameter and smaller may be threaded; joints may also be threaded to accommodate the installation of valves. Provide flanges of the weld neck type to match wall thickness of pipe.

3.9 PIPE JOINTS

Provide pipe joints complying with the requirements of 49 CFR 192, Subpart E for welding of steel pipelines and Subpart F for joints other than welding. Design and install pipe joints to effectively sustain the longitudinal pullout forces and thrust forces caused by the contraction and expansion of piping or superimposed loads. Make each joint in accordance with the submitted and approved written joining procedure that has been proven to produce strong, gas-tight joints. Each joint must be inspected by the approved inspector.

3.9.1 Threaded Steel Joints

Provide threaded joints in steel pipe with tapered threads evenly cut, made with UL approved joint sealing compound approved for gas service or polytetrafluoroethylene tape approved for gas service applied to the male threads only. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.9.2 Welded Steel Joints

Perform gas pipe weldments, as indicated, in accordance with the submitted and approved welding procedures, and by the approved qualified welders. Make changes in direction of piping by welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Use forged or flared branch outlet fittings for improvement of flow where attached to the run, and reinforced against external strains. Perform all beveling, alignment, heat treatment, and inspection of welds conforming to API Std 1104 and the ASME Boiler and Pressure Vessel Code. Remove weld defects and repair the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect it or store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating..

3.9.3 Plastic Pipe Jointing Procedures

Use jointing procedures that have been submitted and approved for this project. Joints in plastic pipe must be made by the qualified personnel submitted and approved for this project, who have the requalification requirements of 49 CFR 192, Section 285. Each joint made must be inspected by the qualified inspector that was submitted and approved for this project.

Heat fusion joining of plastic pipe or fittings made from different plastic resins by classification or by manufacturer are not allowed. If

heat fusion joining of similar polyethylene resin classification is required in pipe made by different manufacturers, the procedure must be qualified by test in accordance with 49 CFR 192, Section 283 requirements and AGA XR0603. The personnel making these joints must be qualified using this procedure in accordance with 49 CFR 192, Section 285 requirements. Submit all data: written procedure, test specimens, test results, inspection reports, etc. to show complete jointing qualification per 49 CFR 192 requirements to the COR.

Where joining procedures for plastic pipes by heat fusion cannot be properly qualified, an alternative connection method must be used.

3.9.4 Mechanical Couplings for Plastic Pipe Jointing

Make mechanical joints in accordance with the procedures that have been qualified in accordance with 49 CFR 192, Section 283(b). Submit evidence that the five specimen joints configured and tested in accordance with 283(b)(1), (2) and (3) failed in a manner consistent with 283(b)(4), (5) and (6) as applicable. For the mechanical coupling, obtain the manufacturer's model number, serial number, and date of manufacture, record the date of installation and obtain the Geographical Information System (GIS) location of the installed mechanical coupling. Submit to the COR, this and all other data required by 49 CFR 192 to be submitted to the Pipeline and Hazardous Material Safety Administration (PHMSA).

3.9.5 Connections Between Metallic and Plastic Piping

Only make metallic to plastic connections outside, underground, and with approved transition fittings.

3.10 VALVES

Install valves in locations shown on the drawings and at locations required by 49 CFR 192. Design valve installation in plastic pipe to protect the plastic pipe against excessive torsional or shearing loads when the valve is operated and from other stresses which may be exerted through the valve or valve box.

For systems where the maximum distribution pressure exceeds 60 psig operating pressure, provide a method to regulate and limit the pressure of the gas in the system that complies with 49 CFR 192.197 paragraphs (c)(1) through (4).

3.11 VALVE BOXES

Provide valve boxes of cast iron not less than 3/16 inch thick at each underground valve except where concrete or other type of housing is indicated. Provide valve boxes with locking covers that require a special wrench for removal, and furnish the correctly marked wrench for each box. Cast the word "GAS" in the box cover. When the valve is located in a roadway, protect the valve box by a suitable concrete slab at least 3 square feet and install an access cover that is traffic rate cast iron of ample thickness to support expected traffic loads. When in a sidewalk, provide the top of the box as a removable concrete slab 2 feet square and set flush with the sidewalk. Make the boxes adjustable extension type with screw or slide-type adjustments. Separately support valve boxes to not rest on the pipe, so that no traffic loads can be transmitted to the pipe. Only locate valves in valve boxes or inside of buildings.

3.12 DRIPS

Install drips conforming to the details, provide commercial units of approved type and capacity. Connect a blow off pipe 1-1/4 inches or larger to each drip at its lowest point and extend to or near the ground surface at a convenient location away from traffic. Provide a reducing fitting for each discharge at each drip terminal (outlet), a plug valve, and a 1/2 inch nipple turned down. Locate the discharge terminal (outlet) inside a length of 12 inches or larger vitrified clay pipe, concrete sewer pipe or concrete terminal box set vertically on a bed of coarse gravel 1 foot thick and 3 feet square, and closed at the ground surface with a suitable replacement cover.

3.13 PRESSURE REGULATOR INSTALLATION

3.13.1 Main Distribution Line Regulators

Install pressure regulators. Install a valve on each side of the regulator for isolating the regulator for maintenance. Install regulators and valves in rectangular reinforced concrete boxes, large enough so that all required equipment can be properly installed, operated, and maintained, with box sidewalls extending above ground line. Provide the boxes with steel door covers with locking provisions and 4 inch diameter vents. Furnish one key or other unlocking device with each cover. Locate discharge stacks, vents, or outlet ports of all pressure relief devices where gas can be discharged into the atmosphere without undue hazard. Provide stacks and vents with fittings to preclude entry of water.

3.13.2 Service Line Regulators

Install a shutoff valve, meter set assembly, and service regulator on the service line outside the building, 18 inches above the ground on the riser. Where steel service lines are used, install an insulating joint on the inlet side of the meter set assembly and service regulator and construct to prevent flow of electrical current. Provide a 3/8 inch tapped fitting equipped with a plug on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.14 METER INSTALLATION

Install meters in accordance with 49 CFR 192. Install permanent gas meters with provisions for isolation and removal for calibration and maintenance, and suitable for operation in conjunction with an energy monitoring and control system. Connect meter complying with the requirements of the Advanced Metering Program that is applied at the particular Government Installation of this project.

3.15 CONNECTIONS TO EXISTING LINES

Make connections between new work and existing gas lines, where required, in accordance with 49 CFR 192, using proper fittings to suit the actual conditions. When connections are made by tapping into a gas main, provide the same size connecting fittings as the pipe being connected.

3.15.1 Connection to Government Owned/Operated Gas Lines

Provide connections to the existing gas lines in accordance with approved procedures. Only perform deactivation of any portion of the existing system at the valve location indicated. Reactivation of any existing gas lines will only be done by the Government. Submit the approved connections to existing lines that is compliant with the requirements of 49 CFR 192, Section 727 prior to making any connections to existing gas lines, manicure the Operating Agency's required procedures which may be obtained from Hunter AAF DPW. Notify the Contracting Officer, in writing, 10 days before connections to existing lines are to be made.

For each pipeline that is to be abandoned in place, submit the approved Connection and Abandonment Plan that is compliant with the requirements of 49 CFR 192, Section 727. Ensure the following steps are taken at a minimum:

- a. For each pipeline that is to be abandoned in place, physically disconnect that from all sources of gas. Purge, cap, plug or otherwise effectively seal the open ends of all abandoned pipelines. Do not complete abandonment until it has been determined that the volume of gas or condensed hydrocarbons contained within the abandoned section poses no potential hazard. Use air or inert gas for purging, or fill the facility with water or other inert material. If air is used for purging, ensure that a combustible mixture is not present after purging.
- b. When a main is abandoned, together with the service lines connected to it, seal the disconnected end of the main and seal the customer's end of each service line as stipulated above.
- c. Where service lines are to be abandoned in place, disconnect the abandoned service lines from the active mains as close to the main as practicable. 49 CFR 192 does not require individual service lines to be sealed.
- d. Close all valves left in the abandoned segment.
- e. Remove all above grade valves, risers, and vault and valve box covers. Fill vault and valve box voids with suitable compacted backfill material.

3.16 CATHODIC PROTECTION

Provide cathodic protection in accordance with NACE SP0169 for all metallic gas piping installed underground and install as specified in Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM.

3.17 TESTS

3.17.1 Destructive Tests of Plastic Pipe Joints

Prior to making heat fusion joints in plastic pipelines, make a joint of each size and type to be installed that day by each person performing joining of plastic pipe that day and destructively test. Make the specimen joint per the approved written procedure. Cut at least 3 longitudinal straps from each joint. Visually examine each strap for voids or discontinuities on the cut surfaces of the joint area. Deform

each of the 3 straps by bending, torque, or impact. Failures are not permitted in the joint area. If a joint fails the visual or deformation test, the qualified joiner who made that joint is not allowed to make further field joints in plastic pipe on this job until that joiner has been retrained and re-qualified. Record and submit the results of the destructive tests including the date and time of the tests, size and type of the joints, ambient conditions, fusion iron temperature and names of inspectors and joiners.

3.17.2 Pressure and Leak Tests

Test the system of gas mains and service lines after construction and before being placed in service, using a test pressure and test medium approved in 49 CFR 192 Subpart J for the applicable conditions of construction. In the event of conflict between the contract test pressure and medium and the test requirements of 49 CFR 192, refer conflict to the COR before continuing with testing. Follow all testing recommendations and safety precautions as recommended by the piping manufacturer's specifications and 49 CFR 192. Follow a written test procedure that ensures all potentially hazardous leaks are discovered. Submit data in booklet form from all pressure tests of the distribution system.

3.17.2.1 Test Pressure

Test each segment of the installed pipeline at the test pressure listed below for the applicable installation:

- a. Strength test steel pipelines operated at a pressure that creates a hoop stress of 30% or more of the Specified Minimum Yield Strength (SMYS), in accordance with 49 CFR 192, Section 505, by hydrostatic testing at a minimum of 125 percent the Maximum Allowable Operating Pressure (MAOP). Maintain strength test pressure for a minimum of 8 hours.
- b. For metallic mains operated at or above 100 psig that produces a hoop stress less than 30 percent SMYS, leak test in accordance with 49 CFR 192, Section 507, by pneumatic testing at a pressure between 100 psig and the pressure required to produce a hoop stress of 20 percent of the SMYS. Maintain test pressure for a minimum of 24 hours.
- c. For metallic mains operated below 100 psig, leak test in accordance with 49 CFR 192, Section 509. Leak test mains operated below 1 psig to a pressure not less than 10 psig. Leak test mains operated at or above 1 psig to a pressure not less than 90 psig. Maintain test pressure for a minimum of 24 hours.
- d. For metallic service lines, leak test in accordance with 49 CFR 192, Section 511. Leak test service lines operated at 40 psig or less to a pressure not less than 50 psig. Leak test service lines operated above 40 psig to a pressure of 90 psig. Ensure that the service line connection to the main is included in this test. Maintain test pressure for a minimum of 24 hours.
- e. For plastic mains and service lines, leak test in accordance with 49 CFR 192, Section 513. Leak test to a pressure at least 150% of the Maximum Allowable Operating Pressure (MAOP) or 50 psig, whichever is greater. Where a compressible gas is used as the test medium, perform pneumatic leak testing of polyethylene (PE) piping in accordance with ASTM F2786 observing the determination of Maximum Test Pressure, which

is calculated using the PE material hydrostatic design stress, the pipe temperature reduction factor and the leak test duration factor. Submit a test procedure that identifies the MAOP of the pipeline, the temperature dependent maximum test pressure, and a step by step procedure for increasing the pipeline pressure as detailed in [ASTM F2786](#) for pneumatic testing or [ASTM F2164](#) for hydrostatic testing. From the beginning of pipeline pressurization to the depressurization of the pipeline the time duration must not exceed 8 hours. If testing must be restarted after maximum test pressure has been reached, depressurize the pipeline for a minimum of 8 hours before restart of pipeline pressurization.

3.17.2.2 Test Performance

Perform testing as follows:

- a. Prior to testing the system, blow-out, clean, and clear the interior of all foreign materials. Remove all meters, regulators, and controls before blowing out and cleaning, and reinstall after clearing of all foreign materials.
- b. Perform testing of gas mains and service lines with due regard for the safety of employees and the public during the test. Keep persons not working on the test operations out of the testing area during testing. Perform the test on the system as a whole or on sections that can be isolated.
- c. Test joints in sections prior to backfilling when trenches are to be backfilled before the completion of other pipeline sections. Continue the test for at least 24 hours from the time of the initial readings to the final readings of pressure and temperature. Do not take the initial test readings of the instrument for at least 1 hour after the pipe has been subjected to the full test pressure. Do not take initial or final readings at times of rapid changes in atmospheric conditions, and temperatures are representative of the actual trench conditions. No indication of reduction of pressure is allowed during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship $T(1)P(2)=T(2)P(1)$, in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial and final readings.
- d. During the test, completely isolate the the entire system from all compressors and other sources of air pressure. Test each joint by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. Secure approval of testing instruments from the Contracting Officer. Furnish all labor, materials and equipment for conducting the tests subject to inspection at all times during the tests. Maintain safety precautions for air pressure testing at all times during the tests.

3.17.3 Meter Test

Test meter to verify data transfer to data collection server and validate calibration of both meter and the data that is received by the data collection server.

3.18 NATURAL GAS COMPRESSORS

Natural gas compressors must be installed in accordance with all

manufacturer's procedures and recommendation. Installations must comply with the design drawings and **API RP 686**.

3.19 MAINTENANCE

Submit operation and maintenance data in accordance with Section **01 78 23** OPERATION AND MAINTENANCE DATA, in three separate packages. Submit Data packages, as specified.

3.19.1 Gas Distribution System and Equipment Operation

Include maps showing piping layout, locations of system valves, gas line markers and cathodic protection system test stations; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system maps); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data Package No. 4 per Section **01 78 23**.

3.19.2 Gas Distribution System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No. 4 per Section **01 78 23**.

3.19.3 Gas Distribution Equipment Maintenance

Include identification of valves and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3 per Section **01 78 23**.

-- End of Section --

SECTION 33 61 13.13

PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION

PART 1 GENERAL

1.1 SUMMARY

The system consists of a buried prefabricated chilled water distribution system including service connections to a point 6 inches inside of the building. The contract drawings show the specific arrangement of piping, sizes and grades of pipe, and other details. The system is designed for an operating pressure of 40 psig and an operating temperature of 54 degrees F for chilled water.

1.2 REFERENCES

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.9	(2018) Factory-Made Wrought Butt welding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B31.1	(2022) Power Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2022) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A234/A234M	(2023a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM C518	(2021) Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C591	(2022) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2996	(2017) Standard Specification for

Filament-Wound "Fiberglass"
(Glass-Fiber-Reinforced
Thermosetting-Resin) Pipe

ASTM D3139

(2019) Joints for Plastic Pressure Pipes
Using Flexible Elastomeric Seals

ASTM D3350

(2021) Polyethylene Plastics Pipe and
Fittings Materials

ASTM D5685

(2019) Standard Specification for
"Fiberglass" (Glass-Fiber-Reinforced
Thermosetting-Resin) Pressure Pipe Fittings

ASTM F477

(2014; R 2021) Standard Specification for
Elastomeric Seals (Gaskets) for Joining
Plastic Pipe

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015

(2016; 14/17) Copper Tube Handbook

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication and Assembly Drawings

SD-03 Product Data

Support of the Equipment

Markers For Underground Piping

SD-07 Certificates

Welding

Written Certification

SD-10 Operation and Maintenance Data

Maintenance; G, R0

1.4 QUALITY ASSURANCE

Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Prior to welding operations, submit a copy of qualified procedures and a list of names and

identification symbols of qualified welders and welding operators. Notify the Contracting Officer 24 hours in advance of tests performed at the work site, if practicable. Apply welder's personal assigned symbol near each weld made as a permanent record. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.5 DELIVERY, STORAGE, AND HANDLING

After delivery to the jobsite, protect all materials and equipment from anything which could cause damage to the material or equipment. Seal piping at each end to keep the interior clean and free of dirt and debris. Keep fittings together and keep their interior surfaces clean at all times. Keep insulation dry and clean.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide system components which are standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Provide a service organization that is, in the opinion of the Contracting Officer, convenient to the site.

Equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for [support of the equipment](#) which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

- a. Submit detail drawings consisting of [fabrication and assembly drawings](#), for all parts of the work in sufficient detail to check conformity with the requirements of the contract documents, prior to installation. In the detail drawings show complete piping, wiring and schematic diagrams and any other details to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout, method of compensation for pipe expansion and contraction, anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances required for maintenance and operation.
- b. Submit the manufacturer's or system fabricator's [written certification](#) stating that the distribution system furnished meets all the requirements of this specification. Clearly identify on the drawings any proposed deviations from the requirements of the contract documents.

2.2 PIPING AND CASING MATERIALS

2.2.1 General

Provide metallic pressure pipe, fittings, and piping accessories that conform to the requirements of [ASME B31.1](#) and are types suitable for the temperature and pressure of the water.

2.2.2 Piping

2.2.2.1 Steel Pipe

Provide piping conforming to [ASTM A53/A53M](#), Grade B, standard weight, black or to [ASTM A106/A106M](#), Grade B, standard weight.

2.2.2.2 Copper Tubing

Provide tubing conforming to [ASTM B88](#), Type K or L.

2.2.2.3 Reinforced Thermosetting Resin Pipe (RTRP)

Provide RTRP conforming to [ASTM D2996](#).

2.2.2.4 Polyvinyl Chloride (PVC) Pipe

Provide PVC piping conforming to [ASTM D2241](#) with a Standard Thermoplastic Pipe Dimension Ratio (SDR) of 26 and PVC 1120 or 1220 as the material.

2.2.2.5 Joints and Fittings for Copper Tubing

Provide wrought copper and bronze solder-joint pressure fittings that conform to [ASME B16.22](#) and [ASTM B75/B75M](#). Provide cast copper alloy solder-joint pressure fittings conforming to [ASME B16.18](#). Provide cast copper alloy fittings for flared copper tube conforming to [ASME B16.26](#) and [ASTM B62](#). Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Design grooved mechanical joints and fittings for not less than [125 psig](#) service. Provide grooved mechanical joints and fittings that are the product of the same manufacturer. Provide grooved fitting and mechanical coupling housing of ductile iron conforming to [ASTM A536](#), with molded synthetic polymer of pressure responsive design conforming to [ASTM D2000](#) for circulating medium up to [230 degrees F](#) and grooved joints conforming to [AWWA C606](#). Provide steel nuts and bolts conforming to [ASTM A183](#) for coupling for use in grooved joints..

2.2.3 Casings

2.2.3.1 Polyvinyl Chloride (PVC) Casing

Provide PVC casings that conform to [ASTM D1784](#), Class 12454-B with a minimum thickness equal to the greater of 1/100 the diameter of the casing or [60 mils](#).

2.2.3.2 Polyethylene (PE) Casing

Provide polyethylene casings conforming to [ASTM D3350](#), Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

Casing Diameter (inches)	Minimum Thickness (mils)
10 and smaller	125

Casing Diameter (inches)	Minimum Thickness (mils)
10 to 18	150
18 through 24	200
over 24	225

2.2.3.3 Reinforced Thermosetting Resin Pipe (RTRP) Casing

Provide RTRP casing of the same material as the pipe, with casing thickness as follows:

Casing Diameter (inches)	Minimum Thickness (mils)
8 and smaller	70
10	80
12	105
14	115
16 to 18	120
20	125
24	155

2.3 PIPING CONNECTIONS

2.3.1 Steel Pipe

For pipe smaller than 0.75 inch, provide Schedule 80 steel pipe with threaded end connections conforming to ASME B1.20.1. Weld all steel pipe 0.75 inch and larger. Provide steel welding fittings conforming to the requirements of ASTM A105/A105M or ASTM A234/A234M. Provide welding fittings conforming to ASME B16.9 for buttweld fittings and ASME B16.11 for socket-weld fittings. Use long radius buttwelding elbows conforming to ASME B16.9 whenever space permits.

2.3.2 Copper Pipe

Braze or provide insulated pipe couplings for copper pipe connections with wrought copper or cast copper alloy solder joint pressure fittings conforming to AWS B2.2/B2.2M and CDA A4015. Provide cast bronze containing an O-ring seal on each end, jacketed and sealed, to act as an expansion joint for insulated pipe couplings for copper pipe.

2.3.3 Plastic Pipe

- a. Provide adhesive bell and spigot type end connections for pipe, fittings, flanges, and couplings. Threaded piping, including pipe,

fittings, flanges, and couplings, will not be permitted.

- b. Flanged Connections: Provide flat face flanged connections between plastic piping and metal piping suitable for connection to ASME Class 150 flanges.
- c. RTRP Piping Sizes: Provide the next larger size where piping sizes other than 2, 3, 4, 6, and 8 inches are indicated with piping connections of the same size or increased to meet the next size of RTRP piping.

2.3.3.1 Plastic Fittings

Provide plastic fittings of the same type and grade of material as the piping to which they will be connected and furnished by the manufacturer who supplies the pipe. Provide temperature and pressure rating for fittings not less than those of the connecting piping.

2.3.3.2 Polyvinyl Chloride (PVC)

Provide solvent welded or connected using bell and spigot connections for polyvinyl chloride (PVC) pipe with solvent used to connect fittings and pipe conforming to the requirements of [ASTM D2564](#). Bell and spigot joints utilizing elastomeric seals conforming to the requirements of [ASTM D3139](#). The elastomeric seals must conform to [ASTM F477](#).

2.3.3.3 Reinforced Thermosetting Resin Plastic (RTRP)

Join reinforced thermosetting resin plastic pipe using fittings and adhesive furnished by the pipe manufacturer in accordance with [ASTM D5685](#).

2.4 END SEALS

Provide pre-insulated sections of pipe with complete sealing of the insulation to provide a permanent water and vapor seal at each end of the pre-insulated section of piping. Provide field modified pre-insulated sections of piping with an end seal which is equivalent to the end seals furnished with the pre-insulated section of piping. Test and certify end seals in accordance with paragraph Casing and End Seal Testing and Certification.

2.4.1 Types

Provide end seals of one of the following types:

- a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe.
- b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. Provide a minimum of 1.5 inch surface bonding area between the cap and both the casing and carrier pipe.
- c. Using elastomeric-ring end seals designed and dimensioned to fit in the annular space between the casing and the carrier pipe.
- d. Using a waterproof mastic seal vapor barrier over the exposed insulation ends.

e. Shrink sleeves.

2.4.2 Casing and End Seal Testing and Certification

Demonstrate that testing and certification procedures by an independent testing laboratory, for casings and end seals, are capable of resisting penetration of water into the casing and insulation. Perform the test on each type of prefabricated system to be furnished. Provide hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure, consisting of 14 days of temperature cycling. Circulate a fluid with a temperature of 40 degrees F through the carrier pipe alternating every 24-hours with a fluid with a temperature of 200 degrees F circulating through the carrier pipe for a low temperature hot water or dual temperature service or 75 degrees F for a chilled water service. While the hot and cold cycle test is being performed, the test sample is either buried or encased in dry bedding sand with a minimum of 12 inches of sand all around the test sample. Restrain the 3 inches diameter carrier pipe of the test sample during the test period. Provide an insulation thickness not to exceed the maximum thickness provided for the piping in the project. Do not exceed transition times for temperature cycle testing of 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe may be water, oil or heat transfer fluid. Immerse the test sample in a water filled chamber following the hot and cold cycling test. Provide a pressure of not less than 20 feet of water head pressure at the highest point over the entire length of the 8 foot test sample for a minimum of the 48 hour test period. Provide water containing a dye penetrant to check for end seal leakage. Upon completion of the pressure test, cut the test sample open using a light that will readily show the presence of the dye that was in the water, inspect the test sample. Evidence of the dye inside the test sample indicates that the end seal is not acceptable and cannot be certified.

2.5 INSULATION

2.5.1 Factory Applied Insulation

Provide factory insulated pre-fabricated pipe and fittings with polyurethane (polyisocyanurate) foam meeting the requirements of ASTM C591 having a density not less than 2 pounds per cubic foot (pcf). Provide the polyurethane (polyisocyanurate) foam completely filling the annular space between the carrier pipe and the casing with an insulation thickness of a minimum of 0.9 inches. Provide an insulation thermal conductivity factor not exceeding the numerical value of 0.15 Btu-inch/square foot-degree F-hour at 75 degrees F, when tested in accordance with ASTM C518. Provide a manufacturer's certification that the insulated pipe is free of insulation voids.

2.5.2 Field Applied Insulation

Provide polyurethane (polyisocyanurate) field applied insulation for fittings, and field casing closures and other piping system accessories, as required, with thickness matching adjacent piping insulation thickness. For buried fittings and accessories, provide field applied polyurethane (polyisocyanurate) insulation to match adjacent piping with a protective covering matching the pipe casing. Provide shrink sleeves with a minimum thickness of 50 mils over casing connection joints.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the project, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the project.

3.2 INSTALLATION

For all pre-insulated, prefabricated systems, obtain the services of a trained representative of the pipe system manufacturer to instruct the Contractor's work forces in the installation procedures to ensure that the system is installed in accordance with the manufacturer's published instructions and the plans and specifications. Provide a manufacturer's representative who regularly performs such duties for the manufacturer. Furnish the Contracting Officer a list of names of personnel trained and certified by the pipe system manufacturer in the installation of this system. Only personnel whose names appear on a less than one year old list will be allowed to install the system.

3.3 PIPING SYSTEMS

3.3.1 Buried Insulated Systems

Provide carrier pipe, insulation, casing, end seals, fittings and accessories for buried insulated systems.

3.4 THRUST BLOCKS

Install thrust blocks at the locations shown or recommended by the pipe system manufacturer. Provide thrust blocks in accordance with manufacturer's recommendations. For systems requiring thrust blocks, at a minimum, provide thrust blocks at all changes in direction, changes in size, valves and terminal ends, such as plugs, caps and tees with concrete having a compressive strength of not less than 2000 psi after 28 days in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Place thrust blocks between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, pour the base and the thrust bearing sides of the thrust blocks directly against undisturbed earth. The sides of the thrust blocks not subject to thrust may be poured against forms. Locate thrust blocks so that the joints for all fittings will be accessible for repair wherever possible. Do not embed joints in concrete unless the assembly has previously been hydrostatically tested. Provide thrust blocks resisted by piles or tie rods to solid foundations in muck or peat, or replace peat or muck with ballast of sufficient stability to resist the thrust blocks.

3.5 INSTALLATION OF PIPING SYSTEMS

Prepare pipe ends to match factory coated ends and install the piping system in accordance with the manufacturer's instructions without springing or forcing other than what has been calculated for cold spring allowing free expansion and contraction without damage to joints or hangers. Do not install copper tubing in a trench with ferrous piping materials. Maintain a minimum vertical separation of 12 inches between pipes when nonferrous metallic pipe (e.g., copper tubing) crosses any ferrous piping material. Provide transition fittings approved by the manufacturer of the piping system for connections between different types

of pipe and system components.

3.5.1 Pitching of Horizontal Piping

Pitch horizontal pipe at a grade of not less than [1 inch in 20 feet](#) toward the drain points unless otherwise indicated.

3.5.2 Open Ends

Provide an approved cap or plug for open ends of pipelines and equipment during installation.

3.5.3 Cutting Prefabricated Piping Sections

Provide new end seals similar to factory applied end seal for field cut prefabricated pipe sections in accordance with the manufacturer's instructions.

3.5.4 Joints

3.5.4.1 Welded Joints

Provide welded joints between sections of pipe and between pipe and fittings where specified or indicated.

3.5.4.2 Threaded Joints

No threaded joints are allowed to be used belowground. Make joints tight with polytetrafluoroethylene tape applied to the male threads only with no more than 3 threads showing after the joint is made up.

3.5.4.3 Grooved Mechanical Joints

Provide grooved fittings, couplings, and grooving tools with products of the same manufacturer. Prepare grooves complying with the tolerances specified by the coupling manufacturer in accordance with the coupling manufacturer's instructions. Measure field made groove diameters using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Measure and record each groove width and dimension from end of pipe for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints are not allowed in concealed locations.

3.5.4.4 Brazed Joints

Brazed joints for copper pipe and fittings must conform to [CDA A4015](#). Utilize brazing alloys melting above [1100 degrees F](#).

3.5.4.5 Nonmetallic Pipe Joints

Install nonmetallic pipe joints in accordance with the written instructions of the manufacturer.

3.5.5 Expansion Loops

If expansion compensation is needed, provide expansion loops and expansion bends (Z- and L- type) factory fabricated of casing, insulation, and carrier piping identical to that furnished for straight runs. Properly

design expansion loops and bends in accordance with the allowable stress limits indicated in [ASME B31.1](#) for the type of pipe used, and size to accommodate pipe movement. Ship expansion loops and bends to the jobsite in the maximum size sections feasible to minimize the number of field joints. Make field joints in straight runs of the expansion loops and bends, keeping the number to a minimum. For steel pipe, cold springing is not allowed when sizing the expansion loops and bends. Cold spring piping one-half the calculated maximum operational expansion during field assembly is allowed. Pipe stress in expansion loops and bends must conform to [ASME B31.1](#).

3.5.6 Anchors

Provide factory fabricated, by the prefabricated system manufacturer, anchor design in accordance with the published data of the manufacturer and for prefabricated systems. Prevent water penetration, condensation, or vapor transmission from wetting/contacting the insulation.

3.5.7 Field Casing Closures

Execution of field insulation and encasement of joints are to be accomplished after the visual and pressure tests specified are completed and in accordance with the manufacturer's written instructions. Provide foamed in place polyurethane insulation with thickness dimensions and casing materials not less than those of the adjoining prefabricated section. Install a standard polyethylene heat shrink sleeve with a [6 inch](#) minimum overlap at each end of the casing.

3.5.8 Underground Warning Tape

Provide underground [0.004 inch](#) thick, [6 inches](#) wide, printed with repetitive caution warnings along its length, polyethylene tape with metallic core warning tape buried above the piping during the trench backfilling approximately [12 inches](#) deep. Provide tapes, yellow in color with black letters; color and lettering must not be affected by moisture or other substances contained in the backfill material.

3.5.9 Markers for Underground Piping

Submit catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents. Place markers for underground piping approximately [2 feet](#) to the right of the distribution system in reference to the fluid flow direction.

Provide concrete markers [6 inch](#) square or round section [2 feet](#) long with the top edge of the marker chamfered at a minimum of [.5 inch](#) all around. Impress of cast letters on the top of the marker with letters CHW to indicate the type of system that is being identified. Form each letter with a V-shaped groove with a width of stroke at least [.25 inch](#) at the top and depth of [.25 inch](#). Provide elevation of markers no more than [1 inches](#) above finished grade.

3.6 EARTHWORK

Perform earthwork in accordance with Section [31 00 00](#) EARTHWORK.

3.7 ELECTRICAL WORK

Perform electrical work in accordance with Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.8 TESTING

Conduct tests before, during, and after installation of the system. Provide all instruments, equipment, facilities, and labor required to properly conduct the tests. Provide test pressure gauges for a specific test with dials indicating not less than 1.5 times nor more than 2 times the test pressure.

3.8.1 Metallic Pipe Welds

Perform radiographic testing in accordance with ASME B31.1. Perform radiographic examination of field welds by an approved independent testing firm or firms regularly engaged in radiographic testing, and interpreted by a Certified Level III Radiographer employed by the testing firm. Review and interpretation of all radiographs must be by a Certified Level III Radiographer employed by the testing firm. Remove, reweld and radiographically examine any welds found to be unacceptable in accordance with the above criteria.

3.8.2 Carrier Pipe Cleaning and Testing

Test distribution piping as required before backfilling, with all joints exposed. The area between joints may be backfilled as necessary to prevent pipe movement.

3.8.2.1 Cleaning Carrier Pipe

Prior to testing, clean the interior of the carrier pipe of foreign materials by thorough flushing with clean water with a circulating water velocity between 2 and 3 m/s (7 and 10 feet per second) for a minimum of 4 hours. Provide temporary and/or supplementary pumps if required to ensure that required velocity is achieved. Clean system strainers after the flushing operation is complete. Temporary strainers must be installed as required. Leave water in the system after flushing for testing of the system to ensure the pipe will maintain pressure and is not leaking.

3.8.2.2 Hydrostatic Pressure Cycling and Tests

Hydrostatic pressure tests consist of 4 cycles; each cycle consisting of a 10 minute period with the first cycle at 150 psig followed by a 5 minute period at a pressure less than 50 psig. Begin the next cycle immediately following the completion of the previous cycle with the pressure rise and drop no more than 100 psi per minute. Locate the pressure gauge and take the pressure measurement at the opposite end of the system from where the pressure is applied. After completion of the hydrostatic pressure cycling, perform the first hydrostatic pressure test proving the system tight at a pressure of 1.5 times the working pressure up to 150 psig and held for a minimum of 1 hour. Disconnect the pressurizing apparatus from the system before starting the 1 hour pressure holding period. Correct any test failures and repeat the hydrostatic pressure cycling and first hydrostatic pressure test until the system can hold the required pressure for at least 1 hour. After successful completion of the first hydrostatic pressure test, drain piping system and fill the piping system as defined in paragraph TREATED WATER for the remaining tests and for permanent

operation of the system. Repeat the hydrostatic pressure cycling and tests for the system after the system has been filled with treated water, using the same test conditions and criteria.

3.8.2.3 Operational Test

Perform operational test on the complete system or testable portions thereof and conduct with full design flows and operating temperatures in all runs of piping as if in service, to demonstrate satisfactory function and operating effectiveness. The operational test will have two cycles. Each cycle must consist of a 6-hour period with treated water in the system at the maximum operating temperature of 60 degrees F and maximum flow rate, and a period of at least 6-hours with no flow. Supply temporary pumps, piping connections, boilers, chillers and the gauges required to circulate the water at the desired temperatures and flow rates. Re-circulate water through supply lines and return through the return piping to demonstrate that the pressure drop is compatible with the flow rate and size of pipe and to show that obstructions do not exist in the piping system. Any unusual indicated pressure drop will be investigated and any obstructions removed. Repair any leaks found. After any obstructions have been removed and any leaks repaired, repeat the operational test until successfully passed.

3.8.2.4 Final Hydrostatic Test

After successful completion of the operational test, pressurize system to 1.5 times the working pressure up to 150 psig and hold for a minimum of 4 hours. Disconnect pressurizing apparatus prior to the start of the 4-hour pressure holding period. Upon test failure, determine the cause of the failure, correct and repeat all of the hydrostatic pressure cycling and pressure tests.

3.9 MAINTENANCE

Submit 6 copies of operation and 6 copies of maintenance manuals for the equipment furnished, 1 complete set prior to performance testing and the remainder upon acceptance. Provide details in the operation manuals showing the step-by-step procedures required for equipment startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include in the maintenance manuals piping and equipment layout and simplified wiring and control diagrams of the equipment system as installed. Provide approved manuals prior to the field performance testing.

-- End of Section --

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO HB-17 (2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318M (2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary

ACI SP-66 (2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B3 (2013) Standard Specification for Soft or Annealed Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM C309 (2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C478 (2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections

ASTM C857 (2016) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

ASTM C990 (2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

ASTM F512 (2019) Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE C2 (2023) National Electrical Safety Code

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA RN 1 (2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA TC 2 (2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NEMA TC 3 (2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing

NEMA TC 6 & 8 (2020) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations

NEMA TC 9 (2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National Electrical Code

SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77 (2013) Specification for Underground Enclosure Integrity

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758 (2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. ARMY INFORMATION SYSTEMS ENGINEERING COMMAND (USISEC)

TC I3A (2017) Technical Criteria for the
Installation Information Infrastructure
Architecture

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644 (2002) Underground Plant Construction

UNDERWRITERS LABORATORIES (UL)

UL 6 (2022) UL Standard for Safety Electrical
Rigid Metal Conduit-Steel

UL 44 (2018; Reprint May 2021) UL Standard for
Safety Thermoset-Insulated Wires and Cables

UL 83 (2017; Reprint Mar 2020) UL Standard for
Safety Thermoplastic-Insulated Wires and
Cables

UL 467 (2022) UL Standard for Safety Grounding
and Bonding Equipment

UL 486A-486B (2018; Reprint May 2021) UL Standard for
Safety Wire Connectors

UL 510 (2020; Dec 2022) UL Standard for Safety
Polyvinyl Chloride, Polyethylene and
Rubber Insulating Tape

UL 514B (2012; Reprint May 2020) Conduit, Tubing
and Cable Fittings

UL 651 (2011; Reprint May 2022) UL Standard for
Safety Schedule 40, 80, Type EB and A
Rigid PVC Conduit and Fittings

UL 854 (2020; Reprint Jan 2022) Standard for
Service-Entrance Cables

1.2 SYSTEM DESCRIPTION

Items provided under this section must be specifically suitable for the following service conditions.

- a. Ambient Temperature 95 degrees F.
- b. Frequency 60 Hz

1.3 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.
- b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast Underground Structures; G, R0

SD-03 Product Data

Precast Concrete Structures; G, R0

Sealing Material; G, R0

Pulling-In Irons; G, R0

Handhole Frames and Covers; G, R0

Composite/Fiberglass Handholes; G, R0

Cable Supports (racks, arms and insulators); G, R0

SD-06 Test Reports

Field Acceptance Checks and Tests; G, R0

Cable Installation Plan and Procedure; G, R0

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

- a. Site layout drawing with cable pulls numerically identified.
- b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.
- c. The cable manufacturer and type of cable.
- d. The dates of cable pulls, time of day, and ambient temperature.
- e. The length of cable pull and calculated cable pulling tensions.
- f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable Installer Qualifications; G, R0

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast handholes bearing the seal of a registered professional engineer including:

- a. Material description (i.e., f'_c and F_y)
- b. Manufacturer's printed assembly and installation instructions
- c. Design calculations
- d. Reinforcing shop drawings in accordance with [ACI SP-66](#)
- e. Plans and elevations showing opening and pulling-in iron locations and details

1.5.2 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of [IEEE C2](#) and [NFPA 70](#) unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-40 or EPC-80 as indicated.

2.1.3 Plastic Duct for Concrete Encasement

Provide Type EB-20 per UL 651, ASTM F512, and NEMA TC 6 & 8.

2.1.4 Fittings

2.1.4.1 Metal Fittings

UL 514B.

2.1.4.2 PVC Conduit Fittings

UL 514B, UL 651 and NEMA TC 3.

2.1.4.3 PVC Duct Fittings

NEMA TC 9.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN

unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 In Duct

Cables must be single-conductor cable.

2.2.4 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags in each handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Color code conductors. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves, or colored electrical tape. Properly identify control circuit terminations. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals may be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems are as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.5 TAPE

2.5.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.5.2 Buried Warning and Identification Tape

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

2.6 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.7 GROUNDING AND BONDING

2.7.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used.

2.7.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.8 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.9 UNDERGROUND STRUCTURES

Provide precast concrete underground structures as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.9.1 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures shall be provided subject to the

requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products.

2.9.1.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures shall be precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.9.1.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

- a. Angle of Internal Friction (ϕ) = 30 degrees
- b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf
- c. Coefficient of Lateral Earth Pressure (K_a) = 0.33
- d. Ground Water Level = 3 feet below ground elevation
- e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.
- f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.
- g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.
- h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.9.1.3 Construction

Provide a uniform thickness for structure top, bottom, and wall not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.9.1.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.9.2 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Provide rolled-steel floor plate covers having an approved antislip surface. Hinges must be of stainless steel with bronze hinge pin, 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method.

2.9.3 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface which must not exceed the design load of the box.

2.10 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

Zinc coat the metal portion of racks and arms after fabrication.

2.10.1 Cable Rack Stanchions

The wall bracket or stanchion must be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes. Space slots for mounting cable rack arms at 8 inch intervals.

2.10.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.10.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.11 CABLE TAGS

Provide polyethylene tags for each power cable located in handholes. Do not provide handwritten letters. The first position on the power cable tag denotes the voltage. The second through sixth positions on the tag identifies the circuit. The next to last position denotes the phase of the circuit and include the Greek "phi" symbol. The last position denotes the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.11.1 Polyethylene Cable Tags

Provide tags of polyethylene having an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag, having a minimum loop tensile strength of 175 pounds and black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.12 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in Section 26 05 73 POWER SYSTEM STUDIES.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758, RUS Bull 1751F-644, and the TC I3A.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. Prepare a checklist of significant requirements and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

- a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.
- b. List of cable installation equipment.
- c. Lubricant manufacturer's application instructions.
- d. Procedure for resealing cable ends to prevent moisture from entering cable.
- e. Cable pulling tension calculations of all cable pulls.
- f. Cable percentage conduit fill.
- g. Cable sidewall bearing pressure.
- h. Cable minimum bend radius and minimum diameter of pulling wheels used.
- i. Cable jam ratio.
- j. Maximum allowable pulling tension on each different type and size of conductor.
- k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide PVC, Type EPC-40, IMC, RGS conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane

forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to [ASTM C309](#). Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. [Handhole](#) locations, as indicated, are approximate. Coordinate exact [handhole](#) locations with other utilities and finished grading and paving.

3.5.1 Precast Concrete Construction

Set commercial precast structures on [6 inches](#) of level, 90 percent compacted granular fill, [3/4 inch to 1 inch](#) size, extending [12 inches](#) beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.2 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor, locate the irons a minimum of [6 inches](#) from the edge of the sump, and in the walls, locate the irons within [6 inches](#) of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within [6 inches](#) of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the [6 inch](#) clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a [3 foot](#) length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of [3 inches](#) from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately [4 inches](#) and must be designed to withstand a minimum pulling-in load of [6000 pounds](#). Hot-dip galvanize irons after fabrication.

3.5.3 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power [handholes](#) not more than [3 feet](#) apart, and provide each [handhole](#) wall with a minimum of two racks. Space racks in signal [handholes](#) not more than [16 1/2 inches](#) apart with the end rack being

no further than 12 inches from the adjacent wall. Methods of anchoring cable racks are as follows:

- a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.
- b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" and cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.
- c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.4 Field Painting

Clean cast-iron frames and covers not buried in concrete or masonry of mortar, rust, grease, dirt and other deleterious materials, and coat with bituminous paint.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Terminate all PVC conduit end points in utility holes, switching cabinets, transform handholes and buildings with end bells. The bell end of the conduits that enter manholes and handholes must be flush with the wall.

Perform changes in ductbank direction as follows:

- a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.
- b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 24 inches for ducts 3 inches or greater in diameter.
- c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections allowed for use in field manufactured longsweep bend: 30 degrees.

3.6.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer whenever an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before being laid. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.6.5 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.6 Conduit Plugs and Pull Rope

Provide new conduit indicated as being unused or empty with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.6.7 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope must be not less than 24 inches below finished grade. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies, prevent floating during concrete pouring by driving reinforcing rods adjacent to

duct spacer assemblies and attaching the rods to the spacer assembly. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.6.7.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.6.7.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.7.3 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks.

3.6.7.4 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one foot apart. Restrain reinforcing assembly from moving during concrete pouring.

3.6.7.5 Removal of Ducts

Where duct lines are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

3.6.8 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.6.9 Tracer Wire

Permanent tracer wire shall be installed in all new duct banks after first

soil lift above concrete encasement. One tracer wire shall be installed per duct bank. The tracer wire shall be #12 AWG, 30 mil PE jacketed (telecommunications shall be orange). After installation, tracer wire shall be tested to verify continuity of the tracer wire system and a report indicating continuity shall be submitted to the permitting authority as part of the as-built construction records.

3.7 CABLE PULLING

Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.8.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Group conductors such that each conduit of a parallel run contains one Phase A conductor, one Phase B conductor, one Phase C conductor, and one neutral conductor.

3.10 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.11 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.12 GROUNDING SYSTEMS

NFPA 70 and **IEEE C2**, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.12.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus **12 inches**, installed to provide an earth ground of the appropriate value for the particular equipment being grounded. If the specified ground resistance is not met, provide an additional ground rod in accordance with the requirements of **NFPA 70** (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.12.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.
- b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.12.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.12.4 Handhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately **12 inches** above finished floor. Secure the conductor to the walls at intervals not exceeding **36 inches**. Connect the conductor to the grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry.

Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.12.5 Fence Grounding

Provide grounding for fences with a ground rod at each fixed gate post and at each corner post. Drive ground rods until the top is 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Bond each gate section to its gatepost by a 1/8 by one inch flexible braided copper strap and ground post clamps. Clamps must be of the anti-electrolysis type.

3.13 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.13.1 Reconditioning of Surfaces

3.13.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.14 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.15 FIELD QUALITY CONTROL

3.15.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.15.1.1 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

- (1) Inspect exposed cable sections for physical damage.
- (2) Verify that cable is supplied and connected in accordance with contract plans and specifications.
- (3) Verify tightness of accessible bolted electrical connections.

- (4) Inspect compression-applied connectors for correct cable match and indentation.
- (5) Visually inspect jacket and insulation condition.
- (6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

- (1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.
- (2) Perform continuity tests to insure correct cable connection.

3.15.1.2 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with [IEEE 81](#). On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.15.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

.... -- End of Section --

SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2016) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C62.61	(1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National
Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-78-B (2020c) FOTP-78 Optical Fibres - Part
1-40: Measurement Methods and Test
Procedures - Attenuation

TIA-455-107 (1999a) FOTP-107 Determination of
Component Reflectance or Link/System
Return Loss using a Loss Test Set

TIA-492E000 (1996; R 2002) Sectional Specification for
Class IVd Nonzero-Dispersion Single-Mode
Optical Fibers for the 1550 nm Window

TIA-526-7 (2015a) OFSTP-7 Measurement of Optical
Power Loss of Installed Single-Mode Fiber
Cable Plant

TIA-568.1 (2020e) Commercial Building
Telecommunications Infrastructure Standard

TIA-568.2 (2018d) Balanced Twisted-Pair
Telecommunications Cabling and Components
Standards

TIA-568.3 (2022e) Optical Fiber Cabling Components
Standard

TIA-569 (2019e; Add 1 2022) Telecommunications
Pathways and Spaces

TIA-590 (1997a) Standard for Physical Location and
Protection of Below Ground Fiber Optic
Cable Plant

TIA-606 (2021d) Administration Standard for
Telecommunications Infrastructure

TIA-607 (2019d) Generic Telecommunications Bonding
and Grounding (Earthing) for Customer
Premises

TIA-758 (2012b) Customer-Owned Outside Plant
Telecommunications Infrastructure Standard

TIA/EIA-455 (1998b) Standard Test Procedure for Fiber
Optic Fibers, Cables, Transducers,
Sensors, Connecting and Terminating
Devices, and Other Fiber Optic Components

TIA/EIA-598 (2014D; Add 2 2018) Optical Fiber Cable
Color Coding

U.S. ARMY INFORMATION SYSTEMS ENGINEERING COMMAND (USISEC)

TC I3A (2017) Technical Criteria for the
Installation Information Infrastructure
Architecture

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755 Telecommunications Standards and
Specifications for Materials, Equipment
and Construction

RUS Bull 345-65 (1985) Shield Bonding Connectors (PE-65)

RUS Bull 345-72 (1985) Filled Splice Closures (PE-74)

RUS Bull 345-83 (1979; Rev Oct 1982) Gas Tube Surge
Arrestors (PE-80)

RUS Bull 1751F-630 (1996) Design of Aerial Plant

RUS Bull 1751F-643 (2002) Underground Plant Design

RUS Bull 1751F-815 (1979) Electrical Protection of Outside
Plant

RUS Bull 1753F-201 (1997) Acceptance Tests of
Telecommunications Plant (PC-4)

RUS Bull 1753F-401 (1995) Splicing Copper and Fiber Optic
Cables (PC-2)

UNDERWRITERS LABORATORIES (UL)

UL 83 (2017; Reprint Mar 2020) UL Standard for
Safety Thermoplastic-Insulated Wires and
Cables

UL 497 (2001; Reprint Jul 2013) Protectors for
Paired Conductor Communication Circuits

UL 510 (2020; Dec 2022) UL Standard for Safety
Polyvinyl Chloride, Polyethylene and
Rubber Insulating Tape

1.2 RELATED REQUIREMENTS

Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM, and Section 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates.
(International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G, R0

Telecommunications Entrance Facility Drawings; G, R0

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Wire and Cable; G, R0

Cable Splices, and Connectors; G, R0

Closures; G, R0

Building Protector Assemblies; G, R0

Protector Modules; G, R0

Spare Parts; G, R0

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation Tests; G, R0

Acceptance Tests; G, R0

Outside Plant Test Plan; G, R0

SD-07 Certificates

Telecommunications Contractor Qualifications; G, R0

Key Personnel Qualifications; G, R0

Minimum Manufacturer's Qualifications; G, R0

SD-08 Manufacturer's Instructions

Building Protector Assembly Installation; G, R0

Cable Tensions; G, R0

Fiber Optic Splices; G, R0

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G, R0

SD-10 Operation and Maintenance Data

Telecommunications Outside Plant (OSP), Data Package 5; G, R0

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). Submit operations and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein not later

than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G, R0

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings. Provide Registered Communications Distribution Designer (RCDD) approved drawings of the telecommunications outside plant. Update existing telecommunication Outside Plant T0 drawings to include information modified, deleted or added as a result of this installation in accordance with TIA-606. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications as specified in the paragraph TELECOMMUNICATIONS SPACE DRAWINGS of Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS. The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Supervisors assigned to the installation of this system or any of its components shall have a minimum Technician certification from BICSI and installers assigned to the installation of this system or any of its components shall have a minimum Level 1 installer certification from BICSI.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project

installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum [Manufacturer's Qualifications](#)

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, [TIA-568.1](#), [TIA-568.2](#) and [TIA-568.3](#). In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with [ICEA S-87-640](#), [ICEA S-98-688](#), and [ICEA S-99-689](#).

1.6.3 [Outside Plant Test Plan](#)

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with [TIA-568.1](#) and [RUS Bull 1753F-201](#). Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements,

manufacturers' catalogs, or brochures during the 2-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 500 feet length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Update existing record documentation to reflect campus distribution T0 drawings and T3 drawing schedule information modified, deleted or added as a result of this installation. Provide the following T5 drawing documentation as a minimum:

- a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.
- b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.8.2 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Spare parts shall be provided no later than the start of field testing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained 5 pin unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for 25 pairs of outside cable. Building protector assembly shall have a cover, splice chamber, and interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturers instructions for building protector assembly installation. Provide copper cable interconnecting hardware as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.2.2 Protector Modules

Provide in accordance with UL 497 three-electrode gas tube or solid state type 5 pin rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be heavy duty, A>10kA, B>400, C>65A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.2.3 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Underground Cable Closures

- a. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which can be poured an encapsulating compound. Closure shall be of suitable thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.2 Fiber Optic Closures

2.3.2.1 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure shall be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure.

2.4 CABLE SPLICES, AND CONNECTORS

2.4.1 Copper Cable Splices

Provide multipair, foldback splices of a moisture resistant, two-wire insulation displacement connector held rigidly in place to assure maximum continuity in accordance with [RUS Bull 1753F-401](#). Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

2.4.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of [0.065 inch](#). Fill connector with sealant grease to make a moisture resistant connection, in accordance with [RUS Bull 1753F-401](#).

2.4.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss shall be [0.05 dB maximum and return loss shall be 55 dB minimum](#). when measured in accordance with [TIA-455-78-B](#) using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of 40.0 db max for single mode fiber when tested in accordance with [TIA-455-107](#). Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.4.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. Splice organizer shall allow for a minimum of [3 feet](#) of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

2.4.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with [RUS Bull 345-65](#).

2.5 CONDUIT

Provide conduit as specified in Section [33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION](#).

2.6 PLASTIC INSULATING TAPE

[UL 510](#).

2.7 WIRE AND CABLE

2.7.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.7.1.1 Underground

Provide filled cable meeting the requirements of [ICEA S-99-689](#) and [RUS 1755.390](#).

2.7.1.2 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of [ICEA S-99-689](#) and [RUS 1755.390](#).

2.7.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1550 nm fiber optic cable in accordance with [TIA-492E000](#) including any special requirements made necessary by a specialized design. Provide [the number of](#) optical fibers as indicated. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with [TIA/EIA-598](#)

2.7.2.1 Strength Members

Provide non-central, metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with [ICEA S-87-640](#). The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.7.2.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with [ICEA S-87-640](#).

2.7.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with [RUS 1755.200](#), [TIA-607](#), [IEEE C2](#), and [NFPA 70](#). Solid bare copper wire meeting the requirements of [ASTM B1](#) for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of [ASTM B8](#), for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of [UL 83](#).

2.8 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be polyethylene and labeled in accordance with TIA-606. Handwritten labeling is unacceptable.

2.8.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.9 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00, EARTHWORK.

2.10 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper.

2.11 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.12 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.13 TESTS, INSPECTIONS, AND VERIFICATIONS

2.13.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568.1 and TIA-568.3. Use TIA-526-7 for single mode fiber. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test

reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions **IEEE C2**, **NFPA 70**, **TIA-758**, **TC I3A**, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Cable Protection

Provide direct burial cable protection in accordance with **NFPA 70** and as specified in Section **33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION**. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of **6 inches per 12 inches** burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40 percent of cross-sectional area, or in concrete encased **4 inches** PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at **6 inches** lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.3.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.1.4 Underground Duct

Provide underground duct and connections to existing manholes, and existing ducts as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

3.1.5 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.6 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. The mandrel shall be 1/2-inch less than the duct's inside diameter. The 12-inch test mandrel shall not pass through ducts with 90-degree sweeps. A 6-inch length test mandrel may be used to test duct runs to buildings. After ducts are mandrelled to verify their integrity, a pull string or pull tape rate at not less than 200-lbs tensile strength shall be installed in each new conduit and innerduct/sub-duct. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.6.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.6.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.6.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.

3.1.7 Cable Splicing

3.1.7.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.7.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.05 dB and return loss not less than 55 dB for fusion splices.

3.1.8 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.9 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.9.1 Primary Bonding Busbar (PBB)

The Primary Bonding Busbar (PBB) is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a PBB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.9.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the PBB.

3.1.9.3 Campus Distributor Grounding

- a. Protection assemblies: Mount CD protector assemblies directly on the telecommunications backboard. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low

resistance path to PBB.

- b. PBB connection: Connect PBB to SBB with copper conductor with a total resistance of less than 0.01 ohms.

3.1.10 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the telecommunications contractor.

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using laser printer.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The labeling of telecommunications cable tag identifiers shall be in accordance with TIA-606. Tag legend shall be as indicated. Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Provide ferrous metallic enclosure finishes as specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 FIELD QUALITY CONTROL

Provide the Contracting Officer 15 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.5.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.5.2 Acceptance Tests

Perform acceptance testing in accordance with **RUS Bull 1753F-201** and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least **15** days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.5.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with **TIA-758**:

- a. Wire map (pin to pin continuity)
- b. Continuity to remote end
- c. Crossed pairs
- d. Reversed pairs
- e. Split pairs
- f. Shorts between two or more conductors

3.5.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with **TIA/EIA-455** and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

- a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, **66 feet** minimum, used as the delay line shall be placed before the new end connector and after the far end

patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber. Splice losses shall not exceed 0.05 db.

- b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 1310 or 1550 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with TIA-526-7 for single-mode fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber.

3.5.3 Soil Density Tests

- a. Determine soil-density relationships for compaction of backfill material in accordance with ASTM D1557, Method D.
- b. Determine soil-density relationships as specified for soil tests in Section 31 00 00 EARTHWORK.

-- End of Section --

SECTION 41 22 13.14

BRIDGE CRANES, OVERHEAD ELECTRIC, TOP RUNNING

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

- AGMA 908** (1989B; R 1999) Information Sheet: Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth
- ANSI/AGMA 2001** (2004D; R 2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
- ANSI/AGMA 2015-1** (2001A; R 2014) Accuracy Classification System - Tangential Measurements for Cylindrical Gears
- ANSI/AGMA 6013** (2006A; R 2016) Standard for Industrial Enclosed Gear Drives
- ANSI/AGMA 6113** (2016B) Standard for Industrial Enclosed Gear Drives (Metric Edition)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

- AISC 360** (2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

- ASCE 7-16** (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- ASME B30.2** (2022) Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)
- ASME B30.10** (2019) Hooks
- ASME HST-4** (2021) Performance Standard for Overhead Electric Wire Rope Hoists
- ASME NOG-1** (2020) Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge,

Multiple Girder)

AMERICAN SOCIETY OF SAFETY PROFESSIONALS (ASSP)

ASSP Z359 (2013) Fall Protection Code

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding
Code - Steel

AWS D14.1/D14.1M (2019) Specification for Welding of
Industrial and Mill Cranes and Other
Material Handling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM A275/A275M (2018; R 2023) Standard Practice for
Magnetic Particle Examination of Steel
Forgings

ASTM A668/A668M (2023) Standard Specification for Steel
Forgings, Carbon and Alloy, for General
Industrial Use

ASTM A931 (2008; R 2013) Standard Test Method for
Tension Testing of Wire Ropes and Strand

ASTM A1023/A1023M (2021) Standard Specification for Stranded
Carbon Steel Wire Ropes for General
Purposes

ASTM F3125/F3125M (2019) Standard Specification for High
Strength Structural Bolts and Assemblies,
Steel and Alloy Steel, Heat Treated, Inch
Dimensions 120 ksi and 150 ksi Minimum
Tensile Strength, and Metric Dimensions
830 MPa and 1040 MPa Minimum Tensile
Strength

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70 (2020) Specification for Top Running
Bridge and Gantry Type Multiple Girder
Electric Overhead Traveling Cranes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

NEMA ICS 2 (2000; R 2020) Industrial Control and
Systems Controllers, Contactors, and
Overload Relays Rated 600 V

NEMA ICS 5 (2017) Industrial Control and Systems:
Control Circuit and Pilot Devices

NEMA ICS 6 (1993; R 2016) Industrial Control and

Systems: Enclosures

NEMA ICS 8 (2011) Crane and Hoist Controllers

NEMA MG 1 (2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 7 2023; TIA 23-15) National Electrical Code

RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)

RCSC A348 (2020) RCSC Specification for Structural Joints Using High-strength Bolts

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910 Occupational Safety and Health Standards

29 CFR 1910.147 The Control of Hazardous Energy (Lock Out/Tag Out)

29 CFR 1910.179 Overhead and Gantry Cranes

29 CFR 1910.306 Specific Purpose Equipment and Installations

UNDERWRITERS LABORATORIES (UL)

UL 50 (2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations

UL 489 (2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 943 (2016; Reprint Sep 2023) UL Standard for Safety Ground-Fault Circuit-Interrupters

UL 1004-1 (2012; Reprint Nov 2020) UL Standard for Safety Rotating Electrical Machines - General Requirements

UL 1449 (2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices

1.2 DEFINITIONS

- a. Bridge Crane: That part of an overhead crane system consisting of girder(s), end trucks, end ties, walkway, and drive mechanism which carries the trolley(s) and travels along the runway rails parallel to the runway.

- b. Crane Runway: The track system along which the crane operates horizontally, including track hangar rods, track connection devices, and runway structural supports.
- c. Dead Loads: The loads on a structure which remain in a fixed position relative to the structure.
- d. Girder: The principal horizontal beam of the crane bridge. It is supported by the crane end trucks.
- e. Lifted Load: The load consisting of the rated load and the weight of lifting devices attached to the crane such as the load block, bucket, or other supplemental devices.
- f. Pendant: A control for a hoist and a crane. The pendant hangs from the hoist or the crane by a cable at a height that is easy for the operator to reach.
- g. Rated Load: The maximum working load suspended under the load hook.
- h. Standard Commercial Cataloged Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing" on the manufacturer's published product data sheets. These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.
- i. Top Running Crane: An electric overhead traveling crane that runs on rails on top of support girders.
- j. Trolley Load: Weight of the trolley and its associated equipment carried by the trolley wheels.
- k. Operating Environments:
 - (1) General Purpose Service: This applies to most cranes and are, in large measure, the manufacturers' standard designs. Cranes should be classified as General Purpose Service if they are operating in routine environments.
 - (2) Ordnance/Explosives Handling: Cranes handling palletized or unpackaged ammunition, missiles, torpedoes, and other types of ordnance. Minimum requirement of CMAA service class D.
 - (3) Hazardous (Explosive) Environments: Cranes operating in hazardous environments as defined by the cognizant activity safety office must be equipped with electrical safety features that meet NEC Article 500. The activity safety office will identify the specific Class, Division, and Group, as well as the envelope that the hazard exists, to allow proper design and shall list these in this section. Choose materials for mechanical components to minimize the potential for sparking, typically bronze, stainless steel, or aluminum. Hazardous environments are split into two groups: minimum anti-spark protection and maximum anti-spark protection.

(a) Minimum Anti-Spark Protection is used when only the load block enters the explosive area.

(b) Maximum Anti-Spark Protection is used when the hazardous area envelops the entire crane.

1.3 SYSTEM DESCRIPTION

The requirements for the crane runway system and rail supporting structures are specified in Section 05 12 00 STRUCTURAL STEEL, and must conform to AISC 360.

1.3.1 Crane Design Criteria

Cranes will operate in the given spaces and match the runway dimensions and rails indicated. Hook coverage, hook vertical travel, clear hook height, lifting capacity, and load test weight must not be less than that indicated.

1.3.1.1 General

Include the following: Number of cranes 1, located in building identified as SOF Rigging Facility, with the capacity expressed in 25 tons, for each overhead electric traveling (OET) crane. Also clearly locate and identify each multiple girder hoist and system components.

1.3.1.2 Classification

Provide top running overhead electric traveling (OET) multiple girder bridge crane conforming to CMAA 70 service class C for operation in an indoor environment, general purpose ordnance handling service, meeting the requirements of ASME B30.2, with an ambient temperature range of 70 to 100 degrees Fahrenheit. The crane span must be as shown on drawings with a vertical lift of 26 feet minimum hook height and as specified herein.

The crane must be pendant controlled and operate in the spaces and within the loading conditions indicated. The pendant controller must be mounted on a separate festooned cable system from the trolley power supply. The crane must operate on 480-volts AC, 60 Hz, three phase power source. Maximum crane wheel loads (without impact) due to dead, trolley, and lifted loads, with the trolley in any position, must not cause a more severe loading condition in the runway support structure than that produced by the design wheel loads and spacing indicated.

1.3.1.3 Rated Capacity and Speeds

Provide crane with rated capacity of 25 tons. Lower load block or assembly of hook, swivel bearing sheaves, pins, and frame suspended by the hoisting ropes are not considered part of the rated capacity.

Rated (maximum) speeds plus or minus 10 percent (feet/min) for the main hoist, bridge, and trolley at the rated load are specified in the table below. The minimum speed must not exceed the values listed. Values in the table are for a fully loaded crane.

Rated Speeds feet/min		
Description	Minimum	Maximum
Main Hoist	10	25
Trolley	50	125
Bridge	60	160

1.4 VERIFICATION OF DIMENSIONS

The Contractor is responsible for the coordination and proper relation of their work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead Electric Traveling Crane; G, D0

Complete Schematic Wiring Diagram; G, D0

SD-03 Product Data

Gear Reducers; G, D0

Hoist Brakes; G, D0

Travel Brakes; G, D0

Load Blocks and Hooks; G, D0

Wheels; G, D0

Hoists; G, D0

Sheaves; G

Commercial Hoist and Trolley Units; G, D0

End Trucks; G, D0

Bridge Rails; G, D0

End Stops; G, D0

Bumpers; G, D0

Variable Frequency Drives; G, D0

Motors; G, D0

Runway Conductor System; G, D0

Bridge Conductor System; G, D0

Limit Switches; G, D0

Pendant Pushbutton Station; G, D0

Pendant Conductor System; G, D0

Controls; G

Control Parameter Settings; G, D0

Runway Conductor System; G, D0

Bridge Conductor System; G, D0

Capacity Overload Protective Device; G

Load Indicating Device; G, D0

Painting System; G, D0

SD-05 Design Data

Load and Sizing Calculations; G, D0

SD-06 Test Reports

Hook Proof Test; G, D0

Hook Non-destructive Test (NDT); G, D0

Post-erection Inspection; G, D0

Operational Tests; G, D0

Hook Tram Measurement; G, D0

Load Tests; G, D0

SD-07 Certificates

Wire Ropes; G, D0

Crane Runway System; G, D0

Loss of Power Test; G, D0

Coupling Alignment Verification Record; G, D0

Overload Test; G, D0

Brake Adjustment Record; G, D0

Compliance with Listed Standards; G, D0

Hazardous Material; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, D0

1.6 QUALITY ASSURANCE

1.6.1 Manufacturer Qualification

Overhead Electric Traveling Crane must be designed and manufactured by a company with a minimum of 10 years of specialized experience in designing and manufacturing the type of overhead crane required to meet requirements of the Contract Documents. Crane design shall be accomplished by, or directly supervised by, a registered professional engineer (PE). PE licensing must be by a board or agency authorized to license and register professional engineers. The PE may be a Contractor's regular employee or a consultant. The PE's review and attestation of specification compliance and professional responsibility must be signified by his or her PE original seal and dated signature on the final drawings. The professional engineers must only undertake and perform work under this contract in the branch(s) of engineering in which they are licensed.

1.6.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing, and documentation. Submit all crane test data recorded on appropriate test record forms suitable for retention for the life of the crane.

1.6.2.1 Inspection of Steel Castings

Visually inspect and test load-carrying steel castings using the magnetic-particle inspection method. All load bearing components, couplings, shafts, and gears, in the hoist drive train must be rolled or forged steel, except brake drums which may be ductile iron. Methods of repairing the discontinuities is subject to review by the Contracting Officer.

1.6.2.2 Inspection of Hook Assembly

Inspect hook by a magnetic-particle type inspection prior to delivery. Furnish documentation of hook inspection to Contracting Officer prior to field operational testing. As part of the acceptance standard, linear indications greater than 1/16 inch are not allowed. Welding repairs of hook are not permitted. A hook showing linear indications, damage or deformation is not acceptable and must be replaced immediately.

1.6.2.2.1 Hook Non-Destructive Test (NDT)

Magnetic-particle inspect the hook over the entire area in accordance with [ASTM A275/A275M](#). Acceptance standard is no defects. A defect is defined as a linear indication that is greater than [1/16 inch](#) long.

1.6.2.3 Hook Proof Test

Proof test the load hook per [ASME B30.10](#). Perform the proof test prior to Hook NDT.

1.6.3 Certificates

All certifications must be dated and bear the original signature (above the printed name) of the authorized representative of the Contractor or the manufacturer of the items or equipment being certified. Each certification will clearly identify the crane, the drives, components, and location (as applicable) to which it applies:

- a. Submit a [Wire Ropes](#) Certification with the wire rope manufacturer's certification that the rope meets the published breaking strength or the actual breaking strength of a sample taken from the reel and tested. Certification is to be traceable to the hoist, crane, and reel.
- b. Submit a [Crane Runway System](#) Certificate stating that the new crane will operate properly on the runway; if the crane(s) cannot operate without restriction, the Contractor must indicate crane limitations.
- c. Submit a [Hazardous Material](#) Certificate that the crane does not contain hazardous material including asbestos, lead, cadmium, chromium, PCBs, or elemental mercury. Products required for the designing and manufacturing of cranes must not contain the prohibited materials.
- d. Submit a [Loss of Power Test](#) Certificate stating that a test may be performed in which power is removed from the crane while the hoist, bridge, and trolley are in operation.
- e. Submit a Certificate of the [Coupling Alignment Verification Record](#).
- g. Submit an [Overload Test](#) Certificate stating that the crane can be periodically load tested to 125 percent of rated load.
- h. Submit a Certificate of the [Brake Adjustment Record](#). Provide a brake adjustment record and installation/maintenance manuals for each brake on the crane. Each brake measurement must have a tolerance traceable to the associated brake manual or documentation provided by the brake manufacturer, location of measurements, and the actual brake setting. Changes made to settings of the brake, at any time, will void the record.
- i. Submit a Certificate of [Compliance with Listed Standards](#)

1.6.4 Drawings: [Overhead Electric Traveling Crane](#)

- a. Submit drawings showing the general arrangement of all components in plan, elevation, and end views. Show all major features of the crane including: hook approaches on all four sides, clearances and principal

dimensions, assemblies of hoist, trolley and bridge drives, motor nameplate data, overcurrent protective device ratings, and electrical schematic drawings. Include weights and centers of gravity of major components. Provide maximum wheel loads (without impact) and spacing imparted to the crane runway system track beams. Indicate the crane speeds along the runway, the trolley speeds along the bridge girder, and the hoist lifting speeds; all speeds indicated are speeds with hoist loaded with rated crane capacity load.

- b. Submit shop drawings of all fabricated components. Shop drawing quality must be equivalent to the contract drawings accompanying this solicitation. Drawings must be reviewed, signed, and sealed by a registered professional engineer.
- c. Provide integral schedule of crane components on each drawing. The schedule must provide a cross reference between manufacturer data and shop drawings. Components listed on the schedule of crane components must include total quantity, description, original manufacturer, and part number. Distributing agents will not be acceptable in lieu of the original manufacturer.
- d. Provide network control system and network drawings. Network diagram must show equipment locations, names, models, and IP addresses on network communications schematic for all programmable logic controllers, remote terminal unit, supervisory controller, and other network-capable devices. In addition, the drawings shall consist of all software nlock, flow, and ladder diagrams.

1.6.5 Design Data: Load and Sizing Calculations

Submit complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Submit calculations reviewed, signed, and sealed by a registered professional engineer verifying the load cases, sizing of the bridge girders, end trucks, travel drives, brake selections, and overcurrent protection for motors, controllers, and branch circuits. Provide a list of all codes and standards, design assumptions, equations, specified efficiencies, limits, factors of safety, component ratings, and sources of values used. Include free body diagrams or sketches of each load case. Include seismic analysis of crane.

1.6.6 Welding Qualifications and Procedures

Welding must be in accordance with qualified procedures using AWS D14.1/D14.1M as modified. Written welding procedures must specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and not exceed those specified in AWS D14.1/D14.1M and CMAA 70. Welders and welding operators must be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1/D14.1M.

1.7 CRANE SAFETY

Comply with the mandatory and advisory safety requirements of ASME B30.10, ASME B30.2, ASME HST-4, CMAA 70, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306, and all applicable provisions of 29 CFR 1910 and NFPA 70. Where personal fall arrest anchorages are provided, design anchorages in accordance with ASSP Z359.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide materials and equipment which are standard products of manufacturers regularly engaged in the fabrication of complete and totally functional cranes including necessary ancillary equipment. Material will be free from defects and imperfections that might affect the serviceability and appearance of the finished product. All material must be new and unused.

2.1.2 Nameplates

Secure nameplates to each major component of equipment with the manufacturer's name, address, type or style, model or catalog number, and serial number. Provide two bridge identification plates, one for each side of the bridge. Provide noncorrosive metal identification plates with letters which are easily read from the floor, showing a separate number such as BC-1, BC-2, for each bridge crane.

2.1.3 Capacity Marking

Mark the rated capacity in **ton** units on each side of the crane on the bridge girders. Capacity marks must be large enough to be clearly visible from the floor. The markings must be positioned to be visible at the operator's position after the crane has been installed.

2.1.4 Safety Warnings

Affix labels in a readable position to each lift block or control station in accordance with **ASME B30.2**. Submit safety warnings, diagrams and other instructions suitably framed and protected for display as indicated by the Contracting Officer as follows:

Design and locate the word "WARNING" or other legend to bring the label to the attention of the operator. Provide durable type warning labels and display the following information concerning safe-operating procedures: Cautionary language against lifting more than the rated load; operating the hoist when the hook is not centered under the hoist; operating hoist with twisted, kinked or damaged rope; operating damaged or malfunctioning hoist; operating a rope hoist with a rope that is not properly seated in its hoist drum groove; lifting people; lifting loads over people; and removing or obscuring the warning label.

2.2 STRUCTURAL REQUIREMENTS

Structural requirements must be in accordance with **CMAA 70**, Section 3. Structural steel materials must conform to the standards permitted in **CMAA 70** and **AISC 360**.

2.2.1 Structural Connections

High-strength bolted structural connections must be designed and installed in accordance with **RCSC A348**. Bolts must be of **ASTM F3125/F3125M** Grade A325/A325M or Grade A490/A490M material. Galvanized bolts are not acceptable.

Welded connections must be performed in accordance with AWS D14.1/D14.1M.
Allowable stress values must comply with CMAA 70.

2.2.2 Bridge Girder or Girders

Provide wide flange beambridge girders. If the ends of bridge girders are notched to fit over the end trucks, the notches must be reinforced with vertical diaphragms and horizontal stiffeners.

2.2.3 Bridge Rails

Provide bridge rails, crane girders and other sections that are straight and true. Make all rail joints flush and true without misalignment of running tread and design to minimize vibration. The gap between adjacent rail ends and the vertical misalignment of running treads shall not exceed 1/32 inch. Solid stock (e.g. square bar, roundstock) is not permitted as bridge rail. Center bridge rail on top flange or position bridge rail over girder web for torsion box girders. Fasten rail to girder with welded clips. Position rail clips in pairs and at not more than 36 inches on center. Bolt bridge rail joints using standard joint bars. Stagger and position rail joints directly over girder diaphragms. Provide a positive stop at bridge rail ends to prevent creep.

2.2.4 End Ties and Bridge Girder End Connections

If equalizing end trucks are used, provide rigid end ties between girders to form a frame that is rigid about the vertical and horizontal axes. If compensating end trucks are used, provide end ties which are rigid about the vertical axis but relatively flexible about the horizontal axis to permit partial rocking motion for wheel load compensation. Provide full depth diaphragms at girder connections and jacking points. Provide horizontal gusset plates at the elevation of top and bottom end tie flanges for connection to girder ends. Make end connections with high-strength bolts in accordance with the Structural Connections section of this specification. Use tapered alignment pins to maintain original shop alignment between bridge girders and end ties/trucks.

2.2.5 End Trucks

Provide rotating type end trucks fabricated from structural steel plate to provide a rigid box section structure. Center wheels between the webs of the box section. Configure bridge and trolley trucks with a feature that limits load movement to 1 inch in the event of wheel or shaft failure. Provide jacking pads for removal of wheel assemblies. Wheel axle bearing seats must be designed such that wheel and axle bearing assembly can be removed with not more than 3 inches of jacking.

2.2.6 Trolley Frame

Provide trolley frame as a one-piece structural steel weldment. Provide pads for the use of jacks or wedges when changing truck wheels. Make all trolley yokes and load bars of drop forged, cast or rolled steel. Equip trolley with permanent lifting attachments.

2.2.7 End Stops and Bumpers

Fit bridge girders with structural steel end stops. Locate stops to permit maximum trolley travel. Fit bridge end trucks and trolley frames with shock-absorbing bumpers capable of decelerating and stopping the

bridge and trolley within the limits stated by 29 CFR 1910 and CMAA 70. Bumpers must fully engage end stops. Mount bumpers so that there is no direct shear on mounting bolts (if any) upon impact. Bumpers must provide adequate clearance between the crane and surrounding structure when compressed to preclude damaging equipment. Ensure bridge and trolley bumper retention in accordance with ASME B30.2. When more than one crane is located and operated on the same runway, bumpers shall be provided on their adjacent ends or on one end of one crane. Fit the other end of the end-truck with a structural steel stop to engage the bumpers of the adjacent crane. Ensure bridge bumpers are properly aligned with runway end stops.

2.2.8 Seismic Forces

Perform a seismic analysis as a part of the design of the crane in accordance with ASCE 7-16 or ASME NOG-1. The seismic analysis must be included in the CMAA 70 extraordinary load case (Case 3). For project locations beyond the scope of ASCE 7-16, a widely accepted design standard may be used for seismic analysis.

2.3 MECHANICAL REQUIREMENTS

- a. Provide steel shafts, gears, keys, and couplings. Cast iron and aluminum used to support components of the hoist power transmission train must be ductile. Gray cast iron load bearing parts are prohibited.
- b. All bearings, except those subject only to small rocker motion, must be anti-friction type. All connections subject only to small rocking motion are to be fitted with bushings or thrust washers in the pivot pin bore, as applicable. Bronze bushings must have provisions for grease lubrication.
- c. All mechanical components must be accurately aligned and positively secured to maintain the alignment. Parts must not be forced into position to obtain apparent alignment.

2.3.1 Hoists

Provide hoist conforming to ASME B30.2 and CMAA 70 service class C or better, double reeved, except as modified and supplemented in this section.

2.3.2 Drives

2.3.2.1 Bridge Drives

Provide either A-1 or A-4 bridge drive arrangement as specified in CMAA 70 consisting of a single electric motor mechanically connected through gear reduction and drive shafts to the drive wheels or separate drive motors at each end of bridge.

Acceleration and deceleration must meet the requirements specified in this section. Gears must conform to applicable AGMA standards. Provide oil tight fully enclosed gear reducers with pressure or splash type lubrication. Bridge travel limit switches are optional.

2.3.2.2 Trolley Drives

Provide complete trolley drive arrangement with a minimum of two wheels

driven by an integral electric motor. Drive mechanism must run in totally enclosed oil bath. Limit switches are optional for drive mechanism. Acceleration and deceleration controls must meet requirements specified in this section.

2.3.3 Load Blocks and Hooks

The load block must be constructed of steel and designed to prevent steel-to-steel contact of moving parts. The block must be fully enclosed, concealing the sheaves and wire ropes, except for wire rope slots and drain holes. The block must be clearly marked with the capacity in pounds on both sides.

Provide an unpainted single barbed forged steel hook complying with ASTM A668/A668M. Hook dimensions must be as shown on the drawings. Fit hook with a safety latch designed to preclude inadvertent displacement of slings from the hook saddle. The hook and hook nut must be removable without unreeving of the hoist. Provide hook nut with a removable type set screw or other similar fastener, installed in a plane parallel to the longitudinal axis of the hook shank. Do not weld hook nut. Hook must be free to rotate through 360 degrees when supporting the test load up to 125 percent of the rated capacity. Provide only hooks which are designed and commercially rated in accordance with CMAA and conforming to ASME B30.10 and CMAA 70.

2.3.4 Wire Ropes

- a. Wire ropes must conform to ASTM A1023/A1023M and be tested as required by ASTM A931. The wire rope must be in a double reeved configuration and equalized with a sheave. Provide wire rope with a minimum design factor of 5 to 1 based on the load experienced at rated capacity and minimum breaking strength of the wire rope.
- b. Provide hoisting ropes with improved plow steel, extra improved plow steel, or extra-extra improved plow steel, regular lay, bright, and uncoated with an independent wire rope, wire strand, or otherwise, steel core. Hot-dipped galvanized wire rope is not permitted.
- c. Maximum hoisting rope fleet angles must be 4 degrees for drums and 4.75 degrees for sheaves. Hoisting rope end connections, other than drum connections, must be speltered sockets with forged steel terminals or swaged fittings installed in a fashion that provides 100 percent of the breaking strength of the wire rope. Provide proof of Wire Rope breaking strength. Wedge sockets or aluminum swages are not permitted on wire rope end connections.

2.3.5 Sheaves

Provide steel sheaves. Minimum pitch diameters must be 16 times the rope diameter for running sheaves, and no less than 12 times the rope diameter for equalizer sheaves. Sheave surfaces which contact wire rope are not to be painted.

2.3.6 Hoist Drum

Provide drum made of steel. Design the drum so that not less than two dead wraps of hoisting rope remain on each anchorage when the hook is in its extreme low position. Drum grooving must be machined right and left hand beginning at the ends and grooving toward the center of the drum.

Minimum drum groove depth must be 0.375 times the rope diameter. Minimum drum groove pitch must be either 1.14 times the rope diameter or the rope diameter plus 1/8 inch, whichever is smaller. Minimum drum pitch diameter must be 16 times the rope diameter. Do not paint, coat, or galvanize the surface of the drum which comes in contact with wire rope.

For wire rope drums installed directly onto the output shaft of the hoist speed reducer without an intermediate flexible coupling, the drum to shaft connection must be a barrel coupling.

2.3.7 Gearing

Provide gearing of the enclosed gear reducers type. Provide steel spur, helical, or herringbone type gears and pinions only. Gearing must conform to ANSI/AGMA 2001 and AGMA 908. Internal and external gear dimensional tolerances must conform to the applicable AGMA standard for tooth geometry and tolerances. Open-type gearing is not acceptable, except for final drives.

2.3.7.1 Gear Reducers

Gear reducers must be integral components of standard hoists or hoist/trolley units of manufacturers regularly engaged in the design and manufacture of hoists or hoist/trolley units for Class A, B, or C cranes. Gear reducers must be designed, manufactured, and rated in accordance with ANSI/AGMA 6113 (ANSI/AGMA 6013) (for trolley drives only), as applicable. Except for final reduction, the gear reduction units must be fully enclosed in oil-tight housing. Gearing must be designed to AGMA standards and operate in an oil bath. Operation must be smooth and quiet.

2.3.7.2 Open Gearing

Provide all gears and pinions with adequate strength and durability for the crane service class and manufactured to ANSI/AGMA 2015-1 Accuracy Grade A8 or better. Open gears must be enclosed with safety guards provided with openings with covers for inspection and access for grease lubrication.

2.3.8 Wheels

Provide double flanged, straight tread trolley and bridge travel wheels of rolled-to-shape or roll-forged steel. The rim, flanges, and wheel tread must be hardened to not less than 320 Brinell Hardness Number (BHN). Wheel sizing and flange-to-rail head clearances must be in accordance with CMAA 70 recommendations.

2.3.9 Bridge and Trolley Travel Brakes

Provide bridge and trolley drives with electro-mechanical brakes or non-freecoasting mechanical drive capable of stopping the motion of the bridge or trolley within a distance in feet equal to 10 percent of the full load speed in feet per minute when traveling at full speed with a full load. Brakes must have an externally accessible means to manually release the brake.

2.3.10 Hoist Brakes

- a. Equip hoist with a minimum of two holding brakes, each with a minimum torque rating of 125 percent of the rated load hoisting torque.

Provide a brake configuration with two electro-mechanical or thruster brakes..

- b. For cranes with two electro-mechanical or thruster brakes, designate each brake as primary or secondary with the primary brake being the brake mounted closer to the motor. Provide the primary brake with a non-time delayed setting and secondary brake with an adjustable setting time delay, set between one to three seconds after the primary brake in any stopping condition. Do not use an uninterruptible power supply (UPS) to create the secondary brake time delay.
- c. Electro-mechanical or thruster brake must be adjustable to 50 percent of its rated capacity, and must have an externally accessible means of manual release.

2.3.11 Drip Pans

- a. The crane must be designed to preclude leakage of lubricants onto the lifted loads or the floor. Equipment or components, which cannot be made leak-proof, must be fitted with unpainted corrosion resistant steel drip pans or must have the foundations seal welded to create a dam. Drip pans that utilize liquid sealant to prevent leakage of lubricants are not permitted.
- b. The drip pans must be sized to hold the entire gear case fluid capacity, installed under all drive machinery, designed to permit easy removal of collected lubricant. A trolley floor designed to contain any lubricant drips may be used as fluid containment for any equipment that is mounted on it.
- c. Provide drip pans fitted around the shank of the hook and extending outward to encompass all possible points of lubrication drips from the load block or wire rope. The drip pans must be easily removable without disassembly of the hook or load block and cannot interfere with the crane structure during testing of the upper limits.

2.4 ELECTRICAL REQUIREMENTS

2.4.1 Motors

Motors must meet all applicable requirements of [NEMA MG 1](#) and [UL 1004-1](#). All motors must have a minimum of a 60 minute duty rating and be Totally Enclosed Non Ventilated (TENV), Totally Enclosed Fan Cooled (TEFC), or Totally Enclosed Blower Cooled (TEBC). Provide inverter duty motors for Open Loop [Variable Frequency Drives](#) (VFD). Provide two speed AC squirrel cage induction type motors for the bridge and trolley drives. Provide two speed, AC squirrel cage induction type motor for the hoist. Provide motors with a minimum of Class F insulation. Provide motor overload protection utilizing a thermal sensitive device embedded in its windings.

2.4.2 Controls

- a. Provide static reversing, variable frequency drives (VFD) for the bridge, trolley and hoist electric controls. VFD controllers must meet [NEMA ICS 8](#), Part 8 and at a minimum, provide under-voltage protection, electronic instantaneous over current protection, DC bus over voltage protection, and be able to withstand output line to line shorts without component failure. Select bridge and trolley drives such that the continuous rating of the controller is not less than the

calculated motor full load current based on CMAA 70 5.2.9.1.1.1 and NEC Table 430.250. Select hoist drives such that the continuous rating of the controller is not less than 130 percent of the calculated motor full load current based on CMAA 70 5.2.9.1.1.1 and NEC Table 430.250. All hoist drives must have a motor over-torque limit to lock out the hoist and prevent gross overload of the associated hoist. Provide dynamic braking for each electric drive that is sized per VFD manufacturer's requirements. Submit VFD Control Parameter Settings.

- b. Provide speed control which is infinitely variable for each function, controlled via pendant pushbutton station. Provide controls designed such that the maximum speed of each function will be limited to 25 percent of rated speed when a slow speed switch is actuated on the controller. Energize a yellow/amber light/indicator while in slow speed mode.
- d. The hoist, trolley, and bridge brakes must set after the associated controller decelerates the drive motor to a controlled stop. The hoist, trolley, and bridge controllers must be sized to provide sufficient starting torque to initiate motion of that crane drive mechanism from standstill with 0 to 125 percent of rated load on the hook. The hoist controller must prove torque before release of the brakes and enable the drive motor to develop full torque continuously at zero speed. Motors must operate smoothly at all speeds without torque pulsations, and must only be energized within the frequency range of 50-60 Hz at rated speed.
- e. Provide two-speed magnetic controls for the bridge drive, trolley drive, and hoist drive. Controllers must meet the requirements of NEMA ICS 8. Ensure that an energized drive motor initially rotates only in the direction selected by the operator by activating the corresponding direction; i.e., is not overhauled. For AC squirrel cage motor controllers, the requirements of NEMA ICS 2, Part 2, for general-purpose controllers, must be met.
- f. Provide the bridge and trolley motor control systems with a drift point between OFF and the first speed control point in each direction.
- g. The use of definite purpose contactors is prohibited. If IEC contactors are used, the application cannot exceed the contactor manufacturer's AC3 ratings for the contactor at a minimum.
- h. On hoist function roll-up must be less than 1/8 inch measured at the hook block and roll-back must not occur over the entire load range.
- i. Use of Uninterruptable Power Supplies (UPS) is prohibited. Feed control circuits from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer.
- j. Provide a main line contactor. Energization of the main line contactor must be controlled by the POWER-OFF/POWER-ON switch/pushbutton on all controllers. Upon actuation of the POWER-OFF pushbutton; power to all drive motors, brakes, and controls must be removed. The mainline contactor must not be able to be energize while the POWER-OFF pushbutton is actuated. The POWER-OFF pushbutton circuitry must be independent of all controls or any other electronic

devices.

2.4.3 Protection

Protection must not be less than that required by NEMA ICS 8, CMAA 70, NFPA 70, UL 1004-1, UL 1449, UL 489, UL 50, UL 943, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306 and all applicable provisions of 29 CFR 1910. Provide enclosed type circuit breaker readily accessible to the crane operator for crane disconnect. Provide an On/Off button that removes power from the motors, brakes and control circuit on all operator control stations. Provide for lockout/tagout of all hazardous energy sources.

2.4.4 Resistors

Provide resistors with natural convection cooling sized as recommended by the VFD OEM and fabricated of corrosion resistant metal; the use of "wire wound" type resistors is prohibited for segments of 8 ohms or less. Mount resistors in substantial, ventilated enclosures constructed entirely of non-combustible materials. Provide resistors with terminals fitted in the coolest position in the enclosure.

2.4.5 Transients and Harmonics Protection

- a. Provide contactors and relays with appropriate Metal Oxide Varistors (MOV) or resistor-capacitor (R-C) surge absorbers installed across the respective coil.
- b. Provide transient protection for electronic drive controllers that is either internal to the drive or via an MOV connected line-to-ground close to the line terminals of the drive.
- c. Provide line reactors rated for continuous duty operation based upon the motor nameplate amperes. With motors of 50 horsepower or greater, harmonics protection must be provided by an isolations transformer or as recommended by the VFD OEM. For a drive motor branch circuit that exceeds 150 feet in length, a reactor must also be connected in series with the controller load (output) terminals to provide standing wave protection or as otherwise recommended by the VFD or motor OEM.

2.4.6 Limit Switches

- b. Provide primary upper and lower geared limit switches. Geared limits must allow reversing direction to back out of the limit without resetting. The lower limit switch must be set such that there are a minimum of two wraps of rope on the hoist drum.
- c. Provide a backup mechanical hook block activated upper limit switch wired independent of the directional controllers and the primary upper limit switch that removes power from the hoist motor, hoist brake and hoist controls conforming to NEMA ICS 5. The backup limit must require hoist resetting prior to operation of the hoist in any direction.
- d. Travel limit switches must be provided for the bridge and trolley motion to slow the crane to 25 percent of its rated speed 10 feet before the bridge end stops. Limit switches must be mounted rigidly in a manner so as to protect the switch from misalignment or damage. The target/trip arm must be large enough to provide interception given

a misalignment were to occur.

2.4.7 Operator Controls

- a. Provide crane equipped with a pendant pushbutton station .
- c. If VFD controls are not provided, provide directional contactors with both mechanical and electrical interlocks.

2.4.7.1 Pendant Pushbutton Station

The cranes must be controlled from a pendant pushbutton station suspended from the trolley operating the length of the bridge. Provide multiconductor flexible cords for pendant pushbutton stations with No. 16 AWG minimum conductors. Provide a method of strain relief to protect the electrical conductors from damage. Locate the pendant pushbutton station 4 feet above the finished floor. Pushbutton pendant station must have its elements legibly marked and arranged vertically, in order, in accordance with CMAA 70. Provide 2-step infinitely variable pendant pushbuttons for control of the hoist bridge and trolley. Provide pendant pushbuttons for control that spring return to the OFF position. Voltage in the pendant pushbutton station must not exceed 150 Volts AC or 300 Volts DC. Provide a maintained two-position selector switch for slow speed selection.

2.4.7.1.1 Pendant Conductor System

Provide a festoon type pendant conductor system. The festoon cables must be flat cables suspended from carriers riding on an I-beam or C-track. The pendant controller must be capable of traveling the entire length of the bridge and move independently of the trolley. Festoon loops must not extend below the high hook position.

2.4.8 Electrification Systems

2.4.8.1 Runway Conductor System

- a. Provide a rigid runway Conductor Bar System for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. Provide electrification system with three power conductors and an equipment grounding conductor. The crane must be grounded through the runway electrification system. Provide runway conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. If there is any way the hook block or wire rope can swing into the runway electrification, provide a guard installed to prevent contact.

2.4.8.2 Bridge Conductor System

- a. Provide Festoon System for the bridge conductor system utilizing cables suspended from carriers riding on an I-beam or C-track. Conductors must be fabricated from copper. A minimum of 20 percent of the festoon control circuit conductors for each electrification system

must be spares at the time of crane acceptance. The trolley is required to be grounded through this conductor system. Festooned cable loops must not extend low enough to come into contact with any obstructions.

2.4.9 Capacity Overload Protective Device and Load Indicating Device

- a. Provide a capacity overload protective device for all hoist systems using VFD drive capacity overload protection (separate from torque limiting feature of the VFD) . Set hoist capacity overload protection at 80. Hoist capacity overload protection must be adjustable between 80 and 150 percent of hoist capacity. Provide a keyed override or other means to disable the hoist capacity overload protection when performing a load test.
- b. Provide an LID for the main hoists. Provide a display installed on the underside of the bridge of each crane to provide load information from the load indicating system, to be displayed in pounds, for the main hoists. The display must be large enough so that the operator can read the load value from the ground level. The load indicating system capacity is to be compatible with the maximum test load for each hoist. The accuracy of the load indicating system is to be such that the indicated load is not less than 100 percent of the actual load, and not more than 110 percent of the actual load. The load indicating system must be configured with a set point for an overload limit. Provide Tare (zero) functionality at each operator's station for the load indicating system. Any load bearing components used in the LID system must be steel, have a minimum design factor of 5 to 1 based on ultimate tensile strength and a hardness not to exceed HRC 40. Precipitation hardened stainless steel load bearing elements must be aged hardened at a minimum temperature of 1025 degrees F.
- c. Initially, set the torque limiting capability of the VFD (that is separate from the capacity overload protective device) to 150 percent of the motor torque (amperage) necessary to hoist 100 percent load. It may be adjusted up only to avoid nuisance trips and adjusted down if possible while still avoiding nuisance trips.

2.4.10 Enclosures

- a. Provide enclosures for control panels, controls, and brakes in accordance with NEMA 250 and NEMA ICS 6, Classification Type 1 indoor, general purpose . Provide enclosures with listed drains to prevent accumulation of water within the enclosure. There must not be any condensation inside the control panels. If anti-condensation heaters are provided, these heaters must remain energized when the main line contactor is deenergized.
- b. Provide a non-resettable hour meter, connected across the main line contactor, readable from the exterior of the main control panel, to indicate the elapsed number of hours the crane is energized.
- c. Gaskets of enclosures and fixtures, and joints and contact surfaces of hazardous/explosive enclosures must be kept free of any paint to prevent damage during removal and reinstallation of gaskets of enclosures.

2.4.11 Warning Devices

Provide a warning horn that is operable from a push button at the pendant pushbutton . Provide a warning strobe that is illuminated at all times during movement of the hoist, trolley, or bridge function.

2.4.12 Indicator Lights

Provide Indicator Lights mounted in an enclosure on the bottom of the bridge with lights sized and positioned to be visible from the ground. The lights must be the dual-lamp type. Provide a white light to indicate that power is available on the load side of the crane disconnect and a blue light to indicate that the main contactor is energized. Light voltage must be 115 VAC. Provide nameplates that are legible from ground level. The nameplates must read, in their respective order, "POWER AVAILABLE" and "CRANE ENERGIZED". The POWER AVAILABLE light must be supplied by a separate, fused transformer for its energization.

2.5 PAINTING SYSTEM

- a. Remove all grease, oil, and surface debris by solvent wiping or detergent/water scrubbing, prior to blast cleaning. Prepare surfaces to be coated by abrasive blasting to SSPC SP 6/NACE No.3, Commercial Blast Cleaning, or in accordance with the coating manufacturer's requirements, whichever is more stringent.
- b. Use a painting system appropriate for the conditions provided in the Crane Design Criteria section. Paint exposed portions of the crane using a three -coat system as follows: zinc-rich primer consisting of a minimum of 85 percent zinc by weight in the dry film, an anticorrosive epoxy intermediate coat, and an aliphatic polyurethane top coat . All paint products must be supplied by a single manufacturer and free of chromates, lead, and mercury. Apply each coat in accordance with manufacturer's instructions and requirements. Ensure each coat is smooth, even, and free of runs, sags, orange peel, and other defects. Desired color of finish coat is brilliant yellow . Submit product data for painting system.
- c. Coat faying surfaces of bolted connections per RCSC A348, but do not apply finish paint.
- d. Paint the load block brilliant yellow with black diagonal striping. Paint, coatings, or galvanizing on the following items or areas is not acceptable: hoist wire ropes, hooks, hook nuts, running bearing surfaces (including sheaves and wheel treads), grease fittings, or other items not normally painted.
- e. Factory paint electrical and mechanical equipment in accordance with the manufacturer's best standard practice (for the specified environment), except that electrical equipment doors, which expose current-carrying electrical conductors when opened, must be orange.

2.6 IDENTIFICATION PLATES

Furnish and install identification plates. Provide non-corrosive metal identification plates with clearly legible permanent lettering giving the manufacturer's name, model number, serial number, capacity in both kilogram and pound units printed in different colors, and other essential information or identification.

2.6.1 Markings on Crane, Trolley, and Hook

To avoid operation of the crane in the wrong direction, affix the appropriate directions (NORTH, SOUTH, EAST, and WEST) with arrows on the bottom of the girder where they can be easily seen by the operator and from the loading point. Provide labels on the controls with corresponding directional (NORTH, SOUTH, EAST, and WEST) markings. Markings shall agree with the markings on controller. Do not indicate directional arrows on controller.

Mark the hook rated capacity in **pounds** on both sides of the hoist load block.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, and before performing any work, verify all dimensions in the field. The Contractor is responsible for the coordination and proper relation of the contracted work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

3.2 SHOP ASSEMBLY AND TESTS

Shop assemble major components as completely as possible, except for reeving of drums and sheaves. Functionally test the crane system at the construction facility prior to shipment. The Government reserves the right to inspect the crane for compliance with this specification and to witness the functionality tests. Notify the Contracting Officer 14 days prior to starting testing operations.

3.3 ERECTION AND INSTALLATION

Perform the entire crane erection in accordance with manufacturer's instructions under the full-time supervision of the manufacturer's representative.

3.3.1 Mechanical Alignment

Align motors, couplings, brakes, gear boxes and drive components in accordance with manufacturer's instructions. Complete the Coupling Alignment Verification Record.

3.3.2 Electrical Adjustments

Adjust control system in accordance with manufacturer's instructions. Store a copy of all **Control Parameter Settings** (PLC, VFD). Provide the final alignment data on the **Complete Schematic Wiring Diagram**, including but not limited to, timer settings, resistor tap settings, potentiometer settings, test-point voltages, supply voltages, motor voltages, motor currents. Provide the test conditions such as ambient temperature, motor load, date performed and person performing the alignment as part of the Operational Tests report.

3.3.3 Field Welding

Perform welding indoors, where possible. Surface of parts to be welded must be free from rust, scale, paint, grease or other foreign matter. Minimum preheat and interpass temperatures must conform to the requirements of AWS D14.1/D14.1M. Perform welding of girders and beams conforming to AWS D14.1/D14.1M.

3.3.4 Field Painting

Perform painting indoors, where possible. Field painting (including touch-up) must conform to the requirements of the coating manufacturer and as specified in PAINTING SYSTEM.

3.4 FIELD QUALITY CONTROL

3.4.1 Post-Erection Inspection

After erection, the Contractor, the Activity Crane Inspector/Test Director, and the Contracting Officer must jointly inspect the crane bridge and hoist systems and components to determine compliance with specifications and approved submittals. Notify the Contracting Officer 14 days before the inspection. Provide a report of the inspection indicating the crane is considered ready for operational tests.

3.4.2 Operational Tests

Check the clearance envelope of the entire crane prior to picking or traversing any load to ensure there are no obstructions. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the crane is operational. The Contractor must furnish test weights, operating personnel, instruments, and other apparatus necessary to conduct field tests on each crane. Solid weights must be measured using calibrated equipment traceable to National Institute of Standards and Technology (NIST) with a minimum accuracy of plus or minus two percent.

3.4.2.1 No-Load Test

Raise and lower each hook through the full range of normal travel at rated speed for three complete cycles. Raise and lower each hook, testing other speeds of the crane. Verify proper operation of hoist limit switches. Operate the bridge and trolley in each direction the full distance between end stops. Operate through the entire speed range and verify proper brake operation. Verify correct operation of all indication and ancillary devices.

3.4.3 Test Data

Record test data on appropriate test record forms suitable for retention for the life of the crane. Record operating and startup current measurements for hoist, trolley, and bridge motors using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) must be justified or appropriate adjustments performed. In addition, note, investigate, and correct any high temperatures or abnormal

operation of any equipment or machinery. Record hoist, trolley, and bridge speeds during each test cycle.

3.4.4 Hook Tram Measurement

Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus $\frac{1}{64}$ inch). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening from the base measurement is cause for rejection.

3.4.5 Load Tests

Perform the following tests for each hoist, as specified below.

Test loads used in this section are defined as the following:

Wire rope run-in load: 25 – 50 percent of rated load.

Rated load test: 100 percent of rated load.

Overload test: 125 percent of rated load.

3.4.5.1 Wire Rope Run-In

The primary purpose of this procedure is to exercise the newly installed wire rope.

Place the load on the hook. Start at ground level and hoist up to one foot below upper limit at slow speed. Hoist down to lower limit at slow speed. Repeat hoisting and lowering of the load for approximately 10 hoisting cycles, increasing the speed for each cycle. During this test, the capacity overload lockout should not activate.

3.4.5.2 Rated Load Test

3.4.5.2.1 Hoist

- a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes. Verify that maximum beam and girder deflections do not exceed CMAA 70 design limits.

For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

- b. Hoist Mechanical Load Brake (if present): Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method

used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

- c. Raise and lower test load through the full lift range and visually observe smooth control and acceleration between points. Completely stop the machinery at least once in each direction to ensure proper brake operation.
- d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.2.2 Trolley

Operate the trolley (if space is available) the full distance of the bridge rails in each direction with a test load on the hook. Check proper functioning through the range of speeds. Verify proper brake action.

3.4.5.2.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway (if space is available) in one direction with the trolley at the far end of the bridge, and in the opposite direction with the trolley at the opposite end of the bridge. Use extreme caution. Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.4.5.2.4 Trolley Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of trolley travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the trolley stops and that the brake sets properly. Measure the distance required for the trolley to stop.

3.4.5.2.5 Bridge Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed of bridge travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the bridge stops and that the brake sets properly. Measure the distance required for the bridge to stop.

3.4.5.3 Overload Test

3.4.5.3.1 Hoist

Disconnect or adjust the overload limit device to allow the hoist to lift

the test load. Verify proper operation of the overload limit device after it is reconnected.

a. Static Load Test: With the trolley in the center of the bridge span, raise the test load approximately **one foot**. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes.

For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

b. Raise and lower test load and visually observe smooth control. Stop the load during raising and lowering to verify that the brakes holds the load.

c. Hoist Load Brake (if present): Raise test load approximately **5 feet**. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

d. Hoist Loss of Power Test: Raise the test load to approximately **8 feet**. While slowly lowering the test load, disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.3.2 Trolley

Operate the trolley the full distance of the bridge rails in each direction with a test load on the hook (one cycle) through the range of speeds. Verify proper brake action.

3.4.5.3.3 Bridge

With a test load on the hook, operate the bridge for the full length of the runway in one direction with the trolley at the extreme end of the bridge, and in the opposite direction with the trolley at the opposite extreme end of the bridge (one cycle). Check proper functioning through the range of speeds. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.5 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Furnish a qualified experienced manufacturer's field service representative to supervise the crane installation, assist in the performance of the on-site testing, and instruct personnel in the operational and maintenance features of the equipment.

3.6 OPERATION AND MAINTENANCE MANUALS

Provide two hard copies of operation and two hard copies of maintenance manuals for the equipment furnished along with an electronic copy (PDF) of each on a Compact Disc. Provide one complete set prior to performance testing and final copies upon acceptance. Provide operation manuals that detail the step-by-step procedures required for system startup, operation and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and basic operating features. List in the maintenance manuals routine maintenance procedures, including weekly, monthly, semi-annual, and annual required maintenance items, possible breakdowns and repairs, and troubleshooting guides. Also include as-built drawings, piping and equipment layout, design calculations, Control Parameter Settings and printouts of any software, and simplified wiring and control diagrams of the system as installed. Secure approval of operation and maintenance manuals prior to the field training course.

3.7 FIELD TRAINING

Conduct a training course for operating and maintenance staff and provide a copy of the training material to each participant. Provide a training period after the system is functionally completed but prior to final acceptance. Cover all pertinent points involved in operating, starting, stopping, and servicing the equipment, including all major elements of the Operation and Maintenance Manuals. Demonstrate in course instructions all routine maintenance operations such as lubrication, general inspection, and .

3.8 FINAL ACCEPTANCE

Final acceptance of crane system will not be given until Contractor has successfully completed all testing operations, corrected all material and equipment defects, made all proper operation adjustments, and removed paint or overspray on wire rope, hook, and electrical collector bars.

-- End of Section --

SECTION 41 22 23.19

PARACHUTE LIFT SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B30.10 (2019) Hooks

ASME B30.16 (2022) Overhead Underhung and Stationary Hoists

ASME B30.17 (2020) Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoists)

ASME HST-1 (2017) Performance Standard for Electric Chain Hoists

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

AWS D14.1/D14.1M (2019) Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM A275/A275M (2018; R 2023) Standard Practice for Magnetic Particle Examination of Steel Forgings

ASTM F3125/F3125M (2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

[CMAA 74](#) (2020) Specifications for Single Girder
Cranes

MATERIAL HANDLING INDUSTRY OF AMERICA (MHI)

[MHI MH27.1](#) (2016) Specifications for Underhung Cranes
and Monorail Systems

[MHI MH27.2](#) (2009) Specifications for Enclosed Track
Underhung Cranes and Monorail Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

[NEMA ESPG](#) (2009-2010) Electrical Standards and
Product Guide (ESPG)

[NEMA ICS 6](#) (1993; R 2016) Industrial Control and
Systems: Enclosures

[NEMA ICS 8](#) (2011) Crane and Hoist Controllers

[NEMA MG 1](#) (2021) Motors and Generators

[NEMA MG 2](#) (2014) Safety Standard for Construction
and Guide for Selection, Installation and
Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

[NFPA 70](#) (2023; ERTA 7 2023; TIA 23-15) National
Electrical Code

RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)

[RCSC A348](#) (2020) RCSC Specification for Structural
Joints Using High-strength Bolts

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

[SSPC SP 6/NACE No.3](#) (2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

[29 CFR 1910](#) Occupational Safety and Health Standards

[29 CFR 1910.147](#) The Control of Hazardous Energy (Lock
Out/Tag Out)

[29 CFR 1910.306](#) Specific Purpose Equipment and
Installations

U.S. NAVAL SEA SYSTEMS COMMAND (NAVSEA)

[NAVSEA T9074-AS-GIB-010/271](#) (2014; Revision 1) Requirements for

Nondestructive Testing Methods

UNDERWRITERS LABORATORIES (UL)

UL 1004-1

(2012; Reprint Nov 2020) UL Standard for
Safety Rotating Electrical Machines -
General Requirements

1.2 DEFINITIONS

- a. Lifted Load: The load consisting of the rated load and the weight of lifting devices attached to the crane such as the **lifting bar**, **hooks**, or other supplemental devices.
- b. Pendant: A control for a hoist. The pendant hangs from the hoist by a cable at a height that is easy for the operator to reach.
- c. Rated Load: The maximum working load suspended under the load hook.
- d. Standard Commercial Cataloged Product: A product, which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing on the manufacturer's published product data sheets. These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.
- e. Operating Environments:
 - e(1) General Purpose Service: This applies to most **hoists** and are, in large measure, the manufacturers' standard designs. **Hoists** should be classified as General Purpose Service if they are operating in routine environments.
 - e(2) Hazardous (Explosive) Environments: **Hoists** operating in hazardous environments as defined by the cognizant activity safety office must be equipped with electrical safety features that meet **NFPA 70** Article 500. The activity safety office must identify the specific Class, Division, and Group, as well as the envelope that the hazard exists, to allow proper design and must list these in this section. Materials for mechanical components must be chosen to minimize the potential for sparking, typically bronze, stainless steel, or aluminum. Hazardous environments are split into two groups: minimum anti-spark protection and maximum anti-spark protection.
 - (a) Maximum Anti-Spark Protection is used when the hazardous area envelops the entire **parachute lifting system**.

1.3 SYSTEM DESCRIPTION

Provide all necessary engineering, design, labor, and materials for the fabrication, furnishing of equipment, accessories, transportation, delivery, installation, and incidental services required for the complete installation of a fully functional Parachute Lift System. The work of this section shall include, but not necessarily be limited to the following:

- a. The supply and installation of nine (9) Parachute Lift Units with 2,000-pound capacity, each Lifting Unit with helically-grooved cable drums linked by a common drive shaft.
- b. The supply and installation of one (1) horizontal Lift Bar for each Parachute Lift Unit, each Lift Bar with Attachment Hooks as shown in the drawings
- c. The specified load capacity of the Parachute Lift is considered as "below the hook" capacity plus all overload capabilities described in the testing sections of this specification.
- d. Three (3) Motor Control Panels mounted at floor level in equipment room servicing a total of nine (9) parachute lifts. Each motor control panel shall operate only one (1) parachute lift at a time.
- e. Three (3) Local Operator Control Panels mounted at floor level each servicing a series of Three (3) parachute lifts within Group #1, Group #2, and Group #3 respectively, each with Remote Control Pendant receptacle.
- f. Three (3) hand-held Remote Control Pendants, one (1) for each Local Operator Control Panel, each with attached cord and plug.
- g. The supply, installation, commissioning, and load-testing of associated Parachute Lift units including Lift Lines, Lift Bar, and Parachute Hooks.

1.3.1 Lifting System Design Criteria

Lifting system will operate in the given spaces and match the bar dimensions and placement indicated. Hook coverage, hook vertical travel, minimum clear hook height, lifting capacity, and load test weight must not be less than that indicated.

1.3.1.1 General

Include the following: Number of hoists and their locations indicated on Architectural drawings in building identified as "HOIST", with the capacity expressed in tons, for each hoist. Also clearly locate and identify each hoist and system components.

1.3.1.2 Classification

Provide a single point hoist system with electric powered hoist for operation in an indoor environment, general purpose service, with an ambient temperature range of 50 to 90 degrees Fahrenheit in the roof level of the Drying Tower

and 50 to 120 degrees Fahrenheit in the mechanical mezzanine of the Drying Tower. Hoist equipment, materials, installation, examination,

inspection, and workmanship shall conform to the applicable requirements of NFPA 70^{ASME B30.17, ASME B30.16,ASME HST-1}as modified and supplemented by this specification.

The maintenance hoist must be pendant controlled and operate in the spaces and within the loading conditions indicated. The hoist must operate on 460-volts AC, 60 Hz, three phase power source

1.3.1.3 Rated Capacity and Speeds

Provide hoist with a rated capacity as indicated on Architectural drawings. The hook lift capacity and speed shall be the manufacturer's standard within the limits specified. The hoist shall meet the minimum design requirements specified in ASME HST-1, Duty Class H3.

1.4 VERIFICATION OF DIMENSIONS

The Contractor is responsible for the coordination and proper relation of their work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the lifting bar system and notify the Contracting Officer of any discrepancy before finalizing the crane order.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Complete Schematic Wiring Diagram; G, D0

Electrical Drawings; G, D0

SD-03 Product Data

Hoist Brakes; G, D0

Lift Bars and Attachment Hooks; G, D0

Motors; G, D0

Painting System; G

Hoist System; G

Electric Chain Hoist; G

Variable Frequency Drives; G, D0

Motor Control Panel (MCP); G, D0

Operator Control Panels (OCP); G, D0

Remote Control Pendant (RCP); G, D0

SD-05 Design Data

Load and Sizing Calculations; G, D0

Hoist Track System Survey; G, DP

SD-06 Test Reports

Hook Proof Test; G

Hook Non-Destructive Test (NDT); G

Post-Erection Inspection; G

Operational Tests; G

Hook Tram Measurement; G

Load Tests; G

SD-07 Certificates

Load Chain; G

Loss of Power Test; G

Brake Adjustment Record; G

Compliance with all Listed Standards; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

1.6 QUALITY ASSURANCE

1.6.1 Manufacturer Qualification

Parachute lifting system, including sub-system components manufactured by vendors, must be designed and manufactured by a company with a minimum of 10 years of specialized experience in designing and manufacturing the type of **parachute lifting bar system** required to meet requirements of the Contract Documents.

In addition, manufacturer must have the capability to install and service all of the equipment required in this project with a written description of:

- a. The contractor's operation including facilities.
- b. Experience of key staff personnel who would perform the product engineering, project management, drawing supervision, and

installation supervision including resumes, with a narrative describing how the project will be managed.

- c. Experience of Site Superintendent and key installation personnel including resumes, with a narrative describing how the project will be managed.
- d. Provide a list of ten (10) equivalent installations, including facility name, location, Architect/ Engineer, contract amount, and completion date.
- e. Provide catalog sheets or samples showing the ability to provide the equipment for this project.
- f. Provide technical proposal, including a list of proposed quality assurance standards, workmanship standards, use of subcontractors, sub-vendors, and suppliers, including any team arrangements or partnerships, if any.

1.6.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing, and documentation. Submit all **parachute lifting bar system** test data recorded on appropriate test record forms suitable for retention for the life of the **lifting system**.

1.6.2.1 Inspection of Steel Castings

Visually inspect and test load-carrying steel castings using the magnetic-particle inspection method. All load bearing components, shafts, and gears, in the hoist drive train must be rolled or forged steel, except brake drums which may be ductile iron. Methods of repairing the discontinuities is subject to review by the Contracting Officer.

1.6.2.2 Inspection of Hook Assembly

Inspect hook by a magnetic-particle type inspection prior to delivery. Furnish documentation of hook inspection to Contracting Officer prior to field operational testing. As part of the acceptance standard, linear indications greater than 1/16 inch are not allowed. Welding repairs of hook are not permitted. A hook showing linear indications, damage or deformation is not acceptable.

1.6.2.2.1 Hook Non-Destructive Test (NDT)

Magnetic-particle inspect the hook over the entire area in accordance with **ASTM A275/A275M** or **NAVSEA T9074-AS-GIB-010/271**. Acceptance standard is no defects. A defect is defined as a linear indication that is greater than 1/16 inch long.

1.6.2.3 Hook Proof Test

Proof test the load hook per **ASME B30.10**. Perform the proof test prior to Hook NDT.

1.6.3 Drawings

1.6.3.1 Electrical drawings

Provide an electrical riser diagram and interconnection diagram to be used by the electrical contractor for the purpose of planning power and control wiring from the power source.

1.6.3.2 Hoist System

- a. Submit drawings showing the general arrangement of all components in plan, elevation, and end views. Show all major features of the hoist assembly, hook envelope, and the general arrangement of the lifting bar system with switches and curves, details of all structural connections, clearances and principal dimensions. Include weights and centers of gravity of major components.
- b. Submit shop drawings of all fabricated components. Shop drawing quality must be equivalent to the contract drawings accompanying this solicitation. Drawings must be reviewed, signed, and sealed by a licensed professional engineer.
- c. Provide integral schedule of system components on each drawing. The schedule must provide a cross reference between manufacturer data and shop drawings. Components listed on the schedule of parachute lifting system components must include total quantity, description, original manufacturer, and part number. Distributing agents will not be acceptable in lieu of the original manufacturer.

1.6.3.3 Complete Schematic Wiring Diagram

Provide electrical schematic drawings with motor nameplate data, VFD drive nameplate data and overcurrent protective device ratings

1.6.4 Design Data: Load and Sizing Calculations

Submit complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Provide a list of all codes and standards, design assumptions, equations, specified efficiencies, limits, factors of safety, component ratings, and sources of values used. Include free body diagrams or sketches of each load case. Include seismic analysis of hoists.

1.6.5 Certificates

All certifications shall be dated and shall bear the original signature (above the printed name) of the authorized representative of the Contractor or the manufacturer of the items or equipment being certified. Each certification shall clearly identify the hoist, the drives, components, and location (as applicable) to which it applies:

- a. Submit a Load Chain Certification clearly indicating load chain breaking strength for each hoist, and clearly identified for traceability. Submit factory certification of load chain rated capacity.
- b. Submit a Hoist Track System Survey certifying drive shafts have been aligned in accordance with CMAA 74, MHI MH27.1, or MHI MH27.2 as

applicable.

- c. Submit a **Loss of Power Test** Certificate stating that a test may be performed in which power is removed from the **lifting system** while the hoists are in operation.
- d. Submit a Certificate of the **Brake Adjustment Record**. Provide a brake adjustment record and installation/maintenance manuals for each brake . Each brake measurement must have a tolerance traceable to the associated brake manual or documentation provided by the brake manufacturer, location of measurements, and the actual brake setting. Changes made to settings of the brake, at any time, will void the record.
- e. Submit a certificate stating that the hoist, hook, and **lifting system** design and fabrication is in **compliance with all listed standards**.

1.6.6 Welding Qualifications and Procedure

Welding must be in accordance with qualified procedures using **AWS D14.1/D14.1M** as modified. Written welding procedures must specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and not exceed those specified in **AWS D14.1/D14.1M**, **MHI MH27.1**, **MHI MH27.2** and **CMAA 74** as applicable. Welders and welding operators must be qualified in accordance with **AWS D1.1/D1.1M** or **AWS D14.1/D14.1M**.

1.7 SAFETY

Comply with the mandatory and advisory safety requirements of **ASME B30.10**, **ASME B30.16**, **ASME B30.17**, **ASME HST-1**, **29 CFR 1910.147**, **29 CFR 1910.306**, and all applicable provisions of **29 CFR 1910** and **NFPA 70**.

PART 2 PRODUCTS

2.1 PARACHUTE LIFT UNIT COMPONENTS

2.1.1 Gear Reducer

- a. Gear reducers shall be flange-mounted directly to the motor and brake assembly.
- b. Gear reducers shall be enclosed in high strength housing with precisely located gear bearing supports. Each housing shall have sufficient capacity for lubricant, and surface area for adequate heat dissipation.
- c. Gear reducer shall be selected to safely transmit specified torque and horsepower and shall have a service factor of 1.25.
- d. Gear reducer shall be filled with high-temperature synthetic lubricant.

2.1.2 Brake Motors

- a. The Parachute Lift units shall incorporate TEFC 3-phase Brake motors, Class H winding, with integral shaft disc brakes.
- b. Primary brake shall be directly coupled to the prime mover.

- c. Primary brake shall be fail-safe disc brake, spring set and electrically released.
- d. Brake shall stop and hold 200% of the motor full load torque.
- e. Primary motor brake shall be integral to the motor and have a holding force of not less than 131.25% of rated lift capacity.
- f. Provide fast-acting brake action to stop and hold the load. Coordinate brake actuation response for smooth operation.

2.1.3 Secondary Braking

- a. Parachute Lifts shall have redundant braking.
- b. A secondary brake shall be provided with a total holding force of 131.25% of rated lift capacity, independent of the primary brake.
- c. A Secondary brake may be coupled to the input shaft of a second reducer.
- d. Full load Secondary brake(s) coupled directly to the output shaft or driveline are acceptable.
- e. Centrifugal overspeed brakes which do not engage after each movement of the lift do not meet this requirement.

2.1.4 Wire Rope Drums

- a. Provide steel welded cable drums.
- b. Drums shall be machined with helically cut grooves spaced for one single layer of the wire rope lift lines.
- c. Adjacent drums of each Parachute Lift Unit shall be grooved in opposing directions to prevent horizontal "drift" of lift bar in travel between top trim height and bottom trim height.
- d. Pitch diameter of the drum shall not be less than 32 times the rope diameter.
- e. A minimum of three dead wraps of the lifting rope shall remain on each anchorage when the hook is in its extreme low position.

2.1.5 Constraints of Travel

- a. Travel constraining limits for up normal, down normal, and ultimate travel in both directions shall be provided. Normal travel limit switches, when struck, shall not permit operation of the unit, except in the direction away from the limit switch.
- b. Ultimate or Over-travel limit switches, when struck, shall de-energize the motor, and shall not permit travel in any direction until specifically reset at the lift or motor control panel by trained technicians.
- c. Limit Switch device shall be a Rotary Limit Switch with 4 position cams. Limit switch shall incorporate an LVLE circuit.

2.1.6 Controls General

- a. Motor controls shall incorporate NEMA 4 enclosures in accordance with NEMA 250 and NEMA ICS 6. Each enclosure shall bear a UL508A inspection label.
- b. All construction shall be designed for use in damp conditions and a temperature rating of 60 degrees C (140 degrees Fahrenheit).
- c. Controls shall enable variable speed operation.
- d. Provide control of Parachute Lifts from the pushbutton station.

2.1.7 Motor Control Panel (MCP)

- a. The MCP shall be a wall or floor stand mounted enclosure for the control of the Parachute Lifts.
- b. The MCP may be located in a machinery room or electrical room but should not be located at the tower floor where water may puddle.
- c. All components, sockets, devices, and terminals shall be touch-safe construction.
- d. The enclosure shall be equipped with a through the door disconnect switch for interrupting all incoming line voltage.
- e. The controller shall be equipped with an Emergency Stop safety relay system and Emergency Stop line contactor.
- f. A power monitor shall detect the loss of a phase, phase reversal, or an under-voltage condition. These shall trip the Emergency Stop contactor and indicate a fault.
- g. Provide fuse or circuit breaker protection for branch circuit and short circuit protection.
- h. Each lift shall be equipped with an individual line contactor controlled by both the E-Stop system and the overtravel limit switch circuit.
- i. Each lift shall be equipped with an individual AC-3 rated magnetic line contactor controlled by both the E-Stop system and its overtravel limit switch circuit. The output of the line contactor shall feed the VFD.
- j. Provide each lift with lift rated Variable Frequency Drive (VFD). The drive shall be horsepower rated for continuous duty.
- k. Equip VFD with dynamic braking resistor sized for 100% of the regenerated load. Resistors shall be thermally protected.
- l. Motor overload protection shall be thermally compensated for ambient temperature and sized to the motor horsepower and rated for constant duty. Overload protection for each motor, motor controller, and branch circuit conductor shall all conform to the NFPA 70.
- m. Provide overcurrent protection for the control circuit and DC

control circuit power supply. All controls shall be LVLE.

- n. Provide climate control for MCP enclosures unless they are located in a room that has climate control.

2.1.8 Operator Control Panels (OCP)

- a. The OCP's shall provide local user interface in a wall mounted enclosure for activation of Parachute Lifts.
- b. All OCP's including enclosures, pilot devices and operator interface shall be NEMA 4 rated in accordance with NEMA 250 and NEMA ICS 6.
- c. The control station shall contain only LVLE Circuits. All line voltage power supplies shall be located at the motor control panel.
- d. Equip the station with system-based controls consisting of: ON indicator, Emergency Stop pushbutton, Reset pushbutton, Ready indicator. Equip the station with channel controls consisting of a Lift Selector Switch, Speed Potentiometer, Up and Down momentary contact pushbuttons.
- e. Equip one station as the master with a security keyswitch. Provide twelve (12) keys.
- f. Each control station operates only the lifts as designated in its work zone.
- g. Only one (1) lift bar may be raised or lowered at a time within its individual work zone.
- h. All Emergency Stop switches shall be coordinated, such that activation of any E-Stop will disable all lifts within the tower regardless of work zone control station for its operation.
- i. Locate pushbutton station 1.2 m (4 feet) above the finished floor.

2.1.9 Remote Control Pendant (RCP)

- a. Remote Control Pendant shall be a durable hand-held device with control cable feeding from the bottom of the enclosure.
- b. All pendant controls including the enclosure, pilot devices and operator interface shall be NEMA 4 rated in accordance with NEMA 250 and NEMA ICS 6.
- c. The control station shall contain only LVLE Circuits.
- d. Equip the pendant with an Emergency Stop pushbutton and Up and Down Hi/Lo momentary contact pushbuttons.
- e. Provide a cable coiling hook and pendant hook for each RCP.

2.1.10 Electrification

Provide integral electrical work for the Parachute Lift System in accordance with NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 MATERIALS

2.2.1 General

Provide materials and equipment which are standard products of manufacturers regularly engaged in the fabrication of complete and totally functional **lifting systems** including necessary ancillary equipment. Material will be free from defects and imperfections that might affect the serviceability and appearance of the finished product. All material must be new and unused.

2.2.2 Nameplates

Secure nameplates to each major component of equipment with the manufacturer's name, address, type or style, model or catalog number, and serial number. Provide noncorrosive metal identification plates with letters which are easily read from the floor, showing a separate number such as M-1, M-2, for each hoist.

2.2.3 Capacity Marking

Mark the rated capacity in **tons** units on each side of the **lifting bars**. Capacity marks must be large enough to be clearly visible from the floor. Individual hoist units must have their rated capacity clearly marked. Rated capacity must include all accessories below the hook, such as load bars, magnets, grabs, and other weight handling equipment as part of the load to be handled.

2.2.4 Safety Warnings

Affix labels in a readable position to each control station in accordance with **ASME B30.16** and **ASME B30.17**.

2.3 STRUCTURAL REQUIREMENTS

Structural steel materials must conform to the standards permitted in **CMAA 74**, **MHI MH27.1**, **MHI MH27.2** and **AISC 360** as applicable.

2.3.1 Structural Connections

High-strength bolted structural connections must be designed and installed in accordance with **RCSC A348**. Bolts must be of **ASTM F3125/F3125M** Grade A325/A325M or Grade A490/A490M material. Galvanized bolts are not acceptable.

Welded connections for the crane must be performed in accordance with **AWS D14.1/D14.1M**. Welded connections to the building must be performed in accordance with **AWS D1.1/D1.1M**.

2.4 MECHANICAL REQUIREMENTS

Cast iron and aluminum used to support components of the hoist power transmission train must be ductile.

2.4.1 Electric Chain Hoist

Electric chain hoist shall conform to **ASME HST-1**, **NEMA ICS 8**, **NEMA MG 2**, and **NEMA ESPG** except as modified herein.

Hoisting Chain

- a. Provide a welded link load chain.
- b. Provide a chain stop or dead end connection to prevent the load chain from running out of the hoist at its fully extended position.
- c. Provide chain hoists with 3 m (10 foot) lift or more with a load chain bucket.

2.4.2 Hoist Brakes

2.4.2.1 Hoist Mechanical Load Brake

Provide a mechanical load brake that is capable of stopping and holding 125 percent of the hoist's rated load and does not require the load to be raised before being lowered.

Hoist Secondary Brake

Provide a spring set electro-mechanical brake that stops and holds 125 percent of the hoist's rated load. Equip spring set brake with a manual release mechanism that automatically resets when power is applied to the brake. If the hoist has more than one brake, each brake shall independently stop and hold 125 percent of rated capacity.

Lift Bars and Attachment Hooks

Lift Bars

- a. Lift bars shall be rectangular steel tube with a maximum deflection of $L/600$ under fully loaded conditions. .
- b. Steel tube shall be hot-dip galvanized to prevent corrosion.
- c. Lift bar shall be clearly marked in 4" block letters on both sides of lift bars, at both ends, with lift capacity.
- d. Equip lift bars with attachment hooks spaced per the drawings.

Attachment Hooks

- a. At each location on the lift bar, provide a drop forged safety hook fitted with self-closing, spring-loaded stainless steel safety latch. Hooks shall be hot dip galvanized. Hooks shall be load rated for 1000 lb each at a safety factor of 5:1. Hook attachments to lift bars shall be as specified by the system manufacturer.

Provide an unpainted single barbed forged steel hook which complies with **ASME B30.10**. Fit hook with a safety latch designed to preclude inadvertent displacement of slings from the hook saddle. The hook and hook nut must be removable without unreeving of the hoist or disassembly of the block. Provide an easily removable and reusable means to positively secure the hook nut to the hook shank. Do not weld hook nut. Hook must be free to rotate through 360 degrees when supporting the test load up to 125 percent of the rated capacity.

2.5 ELECTRICAL REQUIREMENTS

2.5.1 Motors

Motors must meet all applicable requirements of NEMA MG 1 and UL 1004-1. All motors must have a minimum of a 60 minute duty rating and be Totally Enclosed Non Ventilated (TENV), Totally Enclosed Fan Cooled (TEFC), or Totally Enclosed Blower Cooled (TEBC). Provide inverter duty motors if Variable Frequency Drives (VFD) are used. Provide motors with a minimum of Class F insulation.

Motor overload protection shall be thermally compensated for ambient temperature and sized to the motor horsepower and rated for constant duty. Overload protection for each motor, motor controller, and branch circuit conductor shall all conform to the NFPA 70.

2.6 PAINTING SYSTEM

Remove all grease, oil, and surface debris by solvent wiping or detergent/water scrubbing, prior to blast cleaning. Prepare surfaces to be coated by abrasive blasting to SSPC SP 6/NACE No.3, Commercial Blast Cleaning, or in accordance with the coating manufacturer's requirements, whichever is more stringent.

Use a painting system appropriate for the conditions provided in the Crane Design Criteria section. Paint exposed portions of the crane and crane track system using a three-coat system as follows: zinc-rich primer consisting of a minimum of 77 percent zinc by weight in the dry film, an anticorrosive epoxy intermediate coat, and an aliphatic polyurethane top coat. All paint products must be supplied by a single manufacturer and free of chromates, lead, and mercury. Apply each coat in accordance with manufacturer's instructions and requirements. Ensure each coat is smooth, even, and free of runs, sags, orange peel, and other defects. Desired color of finish coat is brilliant yellow. Submit product data for painting system.

Coat faying surfaces of bolted connections per RCSC A348, but do not apply finish paint.

Paint the load block brilliant yellow with black diagonal striping. Paint, coatings, or galvanizing on the following items or areas is not acceptable: hoist, hooks, hook nuts, running bearing surfaces (including wheel treads), grease fittings, or other items not normally painted.

Factory paint electrical and mechanical equipment including hoist, trolley, and track in accordance with the manufacturer's best standard practice (for the specified environment).

2.7 IDENTIFICATION PLATES

Furnish and install identification plates. Provide non-corrosive metal identification plates with clearly legible permanent lettering giving the manufacturer's name, model number, serial number, capacity in both kilogram and pound units printed in different colors, and other essential information or identification.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, and before performing any work, verify all dimensions in the field. The Contractor is responsible for the coordination and proper relation of the contracted work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the **parachute lifting system** and notify the Contracting Officer of any discrepancy before finalizing the crane order.

3.2 SHOP ASSEMBLY AND TESTS

Shop assemble major components as completely as possible. Functionally test the crane system at the construction facility prior to shipment. The Government reserves the right to inspect the crane for compliance with this specification and to witness the functionality tests. Notify the Contracting Officer 14 days prior to starting testing operations.

3.3 ERECTION AND INSTALLATION

Perform the entire monorail system erection in accordance with manufacturer's instructions under the full-time supervision of the manufacturer's representative.

3.3.1 Electrical Adjustments

Adjust control system in accordance with manufacturer's instructions. Store a copy of all Control Parameter Settings (PLC, VFD, and other microprocessor-controlled equipment). Provide the final settings and configurations on the Complete Schematic Wiring Diagram, including but not limited to, timer settings, resistor tap settings, potentiometer settings, test-point voltages, supply voltages, motor voltages, motor currents. Provide the test conditions such as ambient temperature, motor load, date performed and person performing the configuration as part of the Operational Tests report.

3.3.2 Field Welding

Perform welding indoors, where possible. Surface of parts to be welded must be free from rust, scale, paint, grease, and other foreign matter. Minimum preheat and interpass temperatures must conform to the requirements of **AWS D14.1/D14.1M**.

3.3.3 Field Painting

Perform painting indoors, where possible. Field painting (including touch-up) must conform to the requirements of the coating manufacturer and as specified in the paragraph PAINTING SYSTEM.

3.4 FIELD QUALITY CONTROL

3.4.1 Post-Erection Inspection

After erection, the Contractor, the Activity Inspector/Test Director, and the Contracting Officer must jointly inspect the hoist systems and components to verify compliance with specifications and approved submittals. Notify the Contracting Officer **14** days before the

inspection. Provide a report of the inspection indicating the **lifting system** is considered ready for operational tests.

Document the results of this inspection and submit the post-erection inspection report to the Contracting Officer for approval.

3.4.2 Operational Tests

Check the clearance envelope of the entire **lifting system** prior to picking any load to ensure there are no obstructions. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the **system** is operational. The Contractor must furnish test weights, operating personnel, instruments, and other apparatus necessary to conduct field tests on **each hoist**. Solid weights must be measured using calibrated equipment traceable to National Institute of Standards and Technology (NIST) with a minimum accuracy of plus or minus two percent.

3.4.2.1 No-Load Test

Raise and lower each **lifting bar** through the full range of normal travel at rated speed for three complete cycles. Raise and lower each **lifting bar**, testing other speeds of the **hoist system**. Verify proper operation of hoist limit switches. Operate the **lifting bars** i the full **permissible** distance . Operate through the entire speed range and verify proper brake operation. Verify correct operation of all indication and ancillary devices.

3.4.3 Test Data

Record test data on appropriate test record forms suitable for retention for the life of the **lifting**. Record operating and startup current measurements for hoist - motors using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) must be justified or appropriate adjustments performed. In addition, note, investigate, and correct any high temperatures or abnormal operation of any equipment or machinery. Record hoistspeeds during each test cycle.

3.4.4 Hook Tram Measurement

Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus **1/64 inch**). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening from the base measurement is cause for rejection.

3.4.5 Load Tests

Perform the following tests as specified below.

Test loads used in this section are defined as the following:

Rated load test: 100 percent (plus **5** minus 0) of rated load.

Overload test: 125 percent of rated load.

3.4.5.1 Rated Load Test

Hoist

- a. Static Load Test: Raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes. Measure and verify deflection for the longest lifting bar section do not exceed MHI MH27.1/MHI MH27.2 and L/600 for rolled steel shapes design limits, as applicable.
- b. Hoist Mechanical Load Brake: Raise test load approximately (5 feet). With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again, with the holding brake in the released position start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

- c. Raise and lower test load through the full lift range. Stop the machinery at least once in each direction to ensure proper brake operation.
- d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the system's power source. Verify that the test load does not lower and that the brake is set.

3.4.5.2 Overload Test

Hoist

Disconnect or adjust the overload limit device to allow the hoists to lift the test load. Verify proper operation of the overload limit device after it is reconnected.

- a. Static Load Test: Raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes.

For hoists with primary and secondary holding brakes, raise the test load and release the secondary holding brake while testing the primary holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage secondary holding brake and release the primary

holding brake. Hold for 10 minutes. Observe for lowering of the load, which may indicate malfunction of hoisting components or brakes. Re-engage the primary holding brake. Recheck proper operation of time delay and ensure smooth positive stopping.

- b. Raise and lower test load and visually observe smooth control. Stop the load during raising and lowering to verify that the brakes holds the load.
- c. Hoist Mechanical Load Brake: Raise test load approximately 5 feet. The load brake must hold the test load. Start the test load down at slow speed and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.
- d. Hoist Loss of Power Test: Raise the test load to approximately 8 feet. While slowly lowering the test load, disconnect the system's power source. Verify that the test load does not lower and that the brake is set.

3.5 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Furnish a qualified experienced manufacturer's field service representative to supervise the lifting system installation, assist in the performance of the on-site testing, and instruct personnel in the operational and maintenance features of the equipment.

3.6 OPERATION AND MAINTENANCE MANUALS

Provide two hard copies of operation and two hard copies of maintenance manuals for the equipment furnished along with an electronic copy (PDF) of each on a Compact Disc. Provide one complete set prior to performance testing and final copies upon acceptance. Provide operation manuals that detail the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, parts list, and brief description of all equipment and basic operating features. List in the maintenance manuals routine maintenance procedures, including weekly, monthly, semi-annual, and annual required maintenance items, possible breakdowns and repairs, and troubleshooting guides. Also include as-built drawings, piping and equipment layout, design calculations, Control Parameter Settings and printouts of any software, and simplified wiring and control diagrams of the system as installed. Secure approval of operation and maintenance manuals prior to the field training course.

3.7 FIELD TRAINING

Conduct a training course for lifting system operating and maintenance staff and provide a copy of the training material to each participant. Provide a training period after the system is functionally completed but prior to final acceptance. Cover all pertinent points involved in operating, starting, stopping, and servicing the equipment, including all major elements of the Operation and Maintenance Manuals. Demonstrate in course instructions all routine maintenance operations such as lubrication, general inspection.

3.8 FINAL ACCEPTANCE

Final acceptance of crane system will not be given until Contractor has successfully completed all testing operations, corrected all material and equipment defects, made all proper operation adjustments, and removed paint or overspray on load chain, hook, and electrical collector bars.

-- End of Section --