

**Solicitation No. W912PP23R0009**

**Date: December 2022**



**U.S. ARMY CORPS OF ENGINEERS**

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## **Combat Rescue Helicopter (CRH) Simulator Facility ADAL**

**Solicitation No. W912PP23R0009**

**Kirtland AFB  
New Mexico**

**Ready to Advertise  
Volume 5—Specifications  
Division 26 through Division 41**

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

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017)  
National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2017; Errata 2017) Standard for  
Acceptance Testing Specifications for  
Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1 (2005) American National Standard for  
Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3 (2015) American National Standard for  
Electrical Metallic Tubing (EMT)

ANSI C80.5 (2015) American National Standard for  
Electrical Rigid Aluminum Conduit

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) 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	(2018) 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
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(1992; R 19972014) Standard for Dry-Type Transformers for General Applications
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
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National Electrical Code

NFPA 70E (2018; TIA 18-1; TIA 81-2) Standard for  
Electrical Safety in the Workplace

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1 (2009; Add 2 2011; Add 1 2012) Commercial  
Building Telecommunications Cabling  
Standard

TIA-569 (2015d) Commercial Building Standard for  
Telecommunications Pathways and Spaces

TIA-607 (2015c; Addendum 1 2017) 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 Aug 2017) UL Standard for  
Safety Flexible Metal Conduit

UL 4 (2004; Reprint Feb 2018) UL Standard for  
Safety Armored Cable

UL 6 (2007; Reprint Nov 2014) Electrical Rigid  
Metal Conduit-Steel

UL 6A (2008; Reprint Nov 2014) Electrical Rigid  
Metal Conduit - Aluminum, Red Brass, and  
Stainless Steel

UL 20 (2010; Reprint Feb 2012) General-Use Snap  
Switches

UL 44 (2018) 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 Mar 2019) UL Standard for  
Safety Panelboards

UL 83 (2017) UL Standard for Safety  
Thermoplastic-Insulated Wires and Cables

UL 360	(2013; Reprint Nov 2018) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 486C	(2018) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Dec 2018) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 510	(2017) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Nov 2018) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2017) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 869A	(2006) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters

UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1569	(2018) UL Standard for Safety Metal-Clad Cables
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces

## 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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-02 Shop Drawings

Panelboards

Transformers; G

Cable Trays; G

### SD-03 Product Data

Receptacles

Switches

Transformers

Enclosed Circuit Breakers

Manual Motor Starters

CATV Outlets

Telecommunications Bonding Busbar

Surge Protective Devices

#### SD-06 Test Reports

600-volt Wiring Test

Grounding System Test

Transformer Tests

Ground-fault Receptacle Test

#### SD-09 Manufacturer's Field Reports

Transformer Factory Tests

#### SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5

### 1.4 QUALITY ASSURANCE

#### 1.4.1 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 NFPA 70 unless more stringent requirements are specified or indicated.

#### 1.4.2 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.

#### 1.4.2.1 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.

#### 1.4.2.2 Material and Equipment Manufacturing Date

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

### 1.5 MAINTENANCE

#### 1.5.1 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.

### 1.6 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.

## 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.

##### 2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

#### 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.

##### 2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

#### 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

Die Cast 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.

### 2.3 CABLE TRAYS

NEMA VE 1. Provide the following:

- a. Cable trays: form a wireway system, with a nominal 4 inch depth or as indicated.
- b. Cable trays: constructed of aluminum.
- 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: 12 inches or as indicated.

#### 2.3.1 Basket-Type Cable Trays

Provide size as indicated on drawings.

#### 2.3.2 Ladder-Type Cable Trays

Provide size as indicated on drawings.

### 2.4 OPEN TELECOMMUNICATIONS CABLE SUPPORT

#### 2.4.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Provide zinc-coated steel open top cable supports as indicated.

### 2.5 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

#### 2.5.1 Floor Outlet Boxes

Provide the following:

- a. Boxes: nonadjustable and concrete tight.
- b. Each outlet: consisting of nonmetallic body with threaded openings, or sheet-steel body with knockouts for conduits, adjustable ring, and cover plate with 1 1/4 inch threaded plug.
- c. Telecommunications outlets: consisting of flush, aluminum or stainless steel housing with a receptacle as specified and one inch bushed side opening.
- d. Receptacle outlets: consisting of flush aluminum or stainless steel housing with duplex-type receptacle as specified herein.
- e. Provide gaskets where necessary to ensure watertight installation.

#### 2.5.2 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 telecommunications outlets: 4-11/16 by 4-11/16 by 2 1/8 inches deep.
- 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.

## 2.6 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, damp, or corrosive environments, NEMA Type 3R as indicated. Provide labeling with panel and circuit numbers on boxes.

## 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 12 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: 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
- c. 120/240 volt, single phase: Black and red

#### 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 or Type XHHW or RHW conforming to UL 44, 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 lighting fixtures 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 No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.

##### 2.7.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the Primary Bonding Busbar (PBB) and the electrical service ground

in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

#### 2.7.5 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

#### 2.7.6 Armored Cable

UL 4; NFPA 70, Type AC cable.

#### 2.7.7 Cord Sets and Power-Supply Cords

UL 817.

### 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. Screws: machine-type with countersunk heads in color to match finish of plate.
- f. Sectional type device plates are not be permitted.
- g. 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, single pole, three-way totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

- a. Handles: white thermoplastic.
- 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. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA 1 or 3R, enclosure as indicated per **NEMA ICS 6.**

#### 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: white as per **NEMA WD 1.**
- 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. Provide permanent label indicating panel name and circuit number on faceplate.

##### 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". Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, die-cast metal/aluminum cover plate.

##### 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

Receptacles serving GFGI equipment and telecom room equipment are special purpose. Provide in ratings indicated. Furnish one matching plug with each receptacle.

#### 2.11.5 Plugs

Provide heavy-duty, rubber-covered wire 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.

#### 2.12 PANELBOARDS

Provide panelboards in accordance with the following:

- a. **UL 67** and **UL 50** having a short-circuit current rating as indicated of 10,000 amperes symmetrical minimum for voltages 240 V and below of 14,000 amperes symmetrical minimum for 480 V. Provide short circuit study prior to issuing panelboard submittal.
- 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 drawings.
- 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. Provide new directories for existing panels modified by this project as indicated.
- l. Type directories and mount in holder behind transparent protective covering.
- m. Panelboards: listed and labeled for their intended use.
- n. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

#### 2.12.1 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 PAINTING.
- 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.

#### 2.12.2 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.

##### 2.12.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:.

- a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.
- b. Panelboard: heat rise tested in accordance with **UL 67**, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.
- c. Verification of the testing procedure: provided upon request.
- d. Two neutral assemblies paralleled together with cable is not acceptable.
- e. Nameplates for panelboard rated for use on non-linear loads: marked

"SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.

- f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

### 2.12.3 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. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

#### 2.12.3.1 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.

#### 2.12.3.2 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 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.

### 2.14 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. Provide NEMA 3R enclosure for transformers located exterior with vent guards.
- c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and two 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.

- f. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.
- g. Transformer of 80 degrees C temperature rise: capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.

#### 2.14.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 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.

#### 2.14.2 Transformers With Non-Linear Loads

Provide transformers for non-linear loads in accordance with the following:

- a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.
- b. Transformers are to be UL listed and labeled for K-4 or K-Factor rating as indicated in accordance with UL 1561.
- c. Transformers evaluated by the UL K-Factor evaluation: listed for 80 degrees C average temperature rise only.
- d. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise are not acceptable.
- e. K-Factor rated transformers impedance: allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

#### 2.15 MOTORS

Provide motors in accordance with the following:

- a. Hermetic-type sealed motor compressors: Also comply with UL 984.
- b. 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.
- c. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.
- d. 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.
- e. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.

- f. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.
- g. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.
- h. Use Inverter-Duty motors designed to operate with adjustable speed drive (ASD).

#### 2.15.1 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.

#### 2.15.2 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.

#### 2.15.3 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.

#### 2.15.4 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.

#### 2.16 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

- a. UL 508, NEMA ICS 1, and NEMA ICS 2.



- 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 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.
- 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: 5,000 rms symmetrical amperes.

#### 2.16.1 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.

#### 2.16.2 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.

##### 2.16.2.1 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.

### 2.16.3 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.

### 2.16.4 Enclosures for Motor Controllers

[NEMA ICS 6](#).

### 2.16.5 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.

### 2.16.6 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.

### 2.16.7 Pilot and Indicating Lights

Provide LED cluster lamps.

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

Single pole designed for surface mounting with overload protection.

### 2.18 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, "Mechanical" for mechanical isolation of machines and other equipment.

### 2.19 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.

### 2.20 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

#### 2.20.1 [CATV Outlets](#)

Provide flush mounted, 75-ohm, F-type connector outlet rated from 5 to 1000 MHz in standard electrical outlet boxes with mounting frame.

## 2.20.2 CATV Faceplates

Provide modular faceplates for mounting of CATV Outlets. Faceplate color: match outlet and switch coverplates.

## 2.20.3 Backboards

Provide void-free, fire rated interior grade plywood, 3/4 inch thick, as indicated. Do not cover the fire stamp on the backboard. Coordinate CATV backboard requirements with telecommunications backboard requirements as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING.

## 2.21 GROUNDING AND BONDING EQUIPMENT

### 2.21.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

### 2.21.2 Ground Bus

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

### 2.21.3 Telecommunications Bonding 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 antioxidant to the contact area to control corrosion and reduce contact resistance. Provide a Telecommunications Bonding Busbar in telecommunications rooms and equipment rooms. The Secondary Bonding Busbar (SBB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide telecommunications grounding 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 SBBs with length as indicated;
- c. Listed by a nationally recognized testing laboratory.

## 2.22 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.

## 2.23 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. Provide red laminated plastic label with white center core where indicated for "RED" power.
- f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.
- g. Minimum size of nameplates: one by 2.5 inches.
- h. Lettering size and style: a minimum of 0.25 inch high normal block style.

#### 2.24 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

#### 2.25 FIRESTOPPING MATERIALS

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

#### 2.26 WIREWAYS

UL 870. Material: steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application enclosure per NEMA ICS 6.

#### 2.27 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. SPD must have the same short-circuit current rating as the protected equipment and shall 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).

Provide SPDs per NFPA 780 for the lightning protection system.

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

600V for 120V, single phase system  
600V for 208Y/120V, three phase system  
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 120/240V, three phase system  
1,200V for 208Y/120V, three phase system  
1,800V for 480Y/277V, three phase system

Provide EMI/RFI filtering per [UL 1283](#) for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

## 2.28 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.

## 2.29 SOURCE QUALITY CONTROL

### 2.29.1 [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.

## 2.30 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

## 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 IEEE C2 and to requirements specified herein.

#### 3.1.1 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.

##### 3.1.1.1 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.

##### 3.1.1.2 Metal-Clad Cable

Install in accordance with NFPA 70 and UFC, limited to branch circuits 6 foot whips, Type MC cable.

#### 3.1.2 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 and where conduit will be visible after completion of project.

##### 3.1.2.1 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).

#### 3.1.2.2 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 40 and 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.
- (4) Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

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#### 3.1.2.3 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).

#### 3.1.2.4 Underground Conduit

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

#### 3.1.2.5 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

#### 3.1.2.6 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.



#### 3.1.2.7 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.

#### 3.1.2.8 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC; fiberglass, or PVC, Type EPC-40. PVC, Type EPC-40, unless indicated otherwise. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum [one inch](#) cover over conduit. Where embedded conduits cross building expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than [one inch](#) trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab. Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

#### 3.1.2.9 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.

#### 3.1.2.10 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. 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. 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 watertight 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.

#### 3.1.2.11 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.

#### 3.1.2.12 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.

#### 3.1.2.13 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semi-recessed 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 conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

#### 3.1.2.14 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-C.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.

#### 3.1.2.15 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. Provide distribution system with star topology with empty conduit and pullwire from each outlet to the headend equipment location.

#### 3.1.3 Busway Installation

Comply at minimum with NFPA 70. Install busways parallel with or at right

angles to ceilings, walls, and structural members. Support busways at 5 foot maximum intervals, and brace to prevent lateral movement. Provide fixed type hinges on risers; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam and caulk. Provide expansion joints, but only where bus duct crosses building expansion joints. 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 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. Support in accordance with manufacturer recommendations but at not more than 5-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. 6 AWG bare copper wire throughout cable tray system, and bond to each section, except use bonding tray couplers that are UL listed. 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 6 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. Use of premanufactured firestop sleeves is also acceptable. 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.

#### 3.1.5 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. 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, except that aluminum boxes may be used with aluminum conduit, 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.

#### 3.1.5.1 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. Telecommunications outlets: a minimum of 4 inches square by 2 1/8 inches deep except for wall mounted telephones. Mount outlet boxes flush in finished walls.

#### 3.1.5.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, 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.

#### 3.1.5.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

#### 3.1.6 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. 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 indicated. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet.

#### 3.1.7 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 manufacturer's recommendations. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

##### 3.1.7.1 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.

#### 3.1.8 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.

#### 3.1.9 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.

#### 3.1.10 Electrical Penetrations

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

#### 3.1.11 Grounding and Bonding

Provide in accordance with **NFPA 70**. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, 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. Make ground connection to driven ground rods on exterior of building. Bond additional driven rods together with a minimum of 4 AWG soft bare copper wire buried to a depth of at least 12 inches. 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.

#### 3.1.11.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. 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.

#### 3.1.11.2 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.

#### 3.1.11.3 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. For raised floor equipment rooms in computer and data processing centers, provide a minimum of four, one at each corner, ground buses connected to the

building grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and alterations.

#### 3.1.11.4 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 25 ohms under dry conditions. Where resistance obtained exceeds 25 ohms, contact Contracting Officer for further instructions.

#### 3.1.11.5 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 telecommunications grounding 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.

#### 3.1.12 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.

#### 3.1.13 Government-Furnished Equipment

Contractor rough-in for Government-furnished equipment make connections to Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

#### 3.1.14 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

##### 3.1.14.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

##### 3.1.14.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

##### 3.1.14.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's



power source as indicated.

#### 3.1.14.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Maintain existing circuits of equipment energized. Restore circuits wiring and power which are to remain but were disturbed during demolition back to original condition.

#### 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.

### 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.

### 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. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS. Where field painting of enclosures for panelboards, load centers 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. Provide panel and circuit number where equipment is served from.

### 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 tests.

#### 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 shall 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 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.

### 3.5.6 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.

### 3.5.7 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 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION

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 242 (2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book

IEEE 399 (1997) Brown Book IEEE Recommended Practice for Power Systems Analysis

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1 (2000; R 2015) Standard for Industrial Control and Systems: General Requirements

NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 3 (2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 486E (2015; Reprint Nov 2017Apr 2019) UL Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

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

UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 845	(2005; Reprint Oct 2018) UL Standard for Safety Motor Control Centers
UL 1203	(2013; Reprint Apr 2018) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

## 1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: Two 800 Amp circuit breakers coordinated with the existing main service entrance disconnect. Short Circuit study and Arc Flash study and labels for all panels. Submit arc flash study and install arc flash labels accordingly.

## 1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

### SD-03 Product Data

Fault Current Analysis; G

Protective Device Coordination Study

Equipment

System Coordinator

Installation

### SD-06 Test Reports

Field Testing

### SD-07 Certificates

Devices and Equipment

## 1.4 QUALITY ASSURANCE

### 1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Experience data shall include at least five references for work of a magnitude comparable to this

contract, including points of contact, addresses and telephone numbers.

#### 1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

#### 1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

#### 1.6 PROJECT/SITE CONDITIONS

Submit certificates attesting that all devices or equipment meet the requirements of the contract documents. [Devices and equipment](#) furnished under this section shall be suitable for the site conditions in structural documentation for seismic details.

Altitude	5000
Ambient Temperature	70 degrees <a href="#">F</a>
Frequency	60
Seismic Parameters	See to structural Category D, Risk II

### PART 2 PRODUCTS

#### 2.1 STANDARD PRODUCT

Provide protective devices and [equipment](#) which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening. Submit data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of nonadjustable protective devices.

#### 2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with [UL 489](#).

#### 2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

#### 2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with [NEMA ICS 1](#), [NEMA ICS 2](#), [NEMA ICS 3](#) and [NEMA ICS 6](#), and [UL 508](#) and [UL 845](#).

#### 2.4.1 Thermal-Overload Protection

Each motor of 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

#### 2.4.2 Low-Voltage Motor Overload Relays

##### 2.4.2.1 General

Thermal and magnetic current overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second. Slow units shall be used for motor starting times from 8 to 12 seconds. Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.

##### 2.4.2.2 Construction

Manual reset type thermal relays shall be bimetallic construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

##### 2.4.2.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than 14 degrees F, an ambient temperature-compensated overload relay shall be provided.

#### 2.4.3 Automatic Control Devices

##### 2.4.3.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate horsepower rating.

##### 2.4.3.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

#### 2.4.3.3 Manual/Automatic Selection

- a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.
- b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

### 2.5 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

#### 2.5.1 General

Motor short-circuit protectors shall conform to [UL 508](#) and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of [NFPA 70](#).

#### 2.5.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

#### 2.5.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 5	A-Y

## 2.6 MOLDED-CASE CIRCUIT BREAKERS

### 2.6.1 General

Molded-case circuit breakers shall conform to [UL 489](#) and [UL 489](#). Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to [UL 1203](#).

### 2.6.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with [UL 486E](#). Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

### 2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with [UL 489](#). Ratings shall be coordinated with system X/R ratio.

### 2.6.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with [UL 489](#). Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

### 2.6.5 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic



operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 200 amperes.

#### 2.6.6 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

- a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.
- b. Adjustable long-time delay.
- c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- d. Adjustable short-time delay.
- e. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- f. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.
- h. Adjustable ground-fault delay.

#### 2.6.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through  $I^2t$  to a value less than the  $I^2t$  of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

#### 2.6.8 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

#### 2.6.9 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

#### 2.6.10 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to [UL 489](#) and [UL 489](#) and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with [NFPA 70](#).

### 2.7 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a [fault current analysis](#), a [protective device coordination study](#), and arc flash study associated printed labels. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

#### 2.7.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the nearest upstream device in the existing source system and extend through the downstream devices at the load end.

#### 2.7.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Utilize the fault current availability indicated as a basis for fault current studies.

#### 2.7.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

## 2.7.4 Fault Current Analysis

### 2.7.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, and IEEE 399.

### 2.7.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

### 2.7.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

### 2.7.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided 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 (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. 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) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

### 2.7.6 Study report

- a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.
- c. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

## PART 3 EXECUTION

### 3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before

performing any work.

### 3.2 INSTALLATION

Submit procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment. Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

### 3.3 FIELD TESTING

Prior to field tests, submit the proposed test plan consisting of complete field test procedure, tests to be performed, test equipment required, and tolerance limits, and complete testing and verification of the ground fault protection equipment, where used. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

#### 3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 3 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

#### 3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

#### 3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

-- End of Section --

SECTION 26 29 23

VARIABLE FREQUENCY DRIVE 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.

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 (2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
- NEMA ICS 1 (2000; R 2015) Standard for Industrial Control and Systems: General Requirements
- NEMA ICS 3.1 (2009; R 2014) 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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

- MIL-STD-461 (2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

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

47 CFR 15

Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489

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

UL 508C

(2002; Reprint Nov 2010) Power Conversion  
Equipment

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM apply to this section with  
additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15, MIL-STD-461 rules and  
regulations, shall be certified to comply with the requirements for class  
A computing devices and labeled as set forth in part 15.

1.3.1.2 Electromechanical and Electrical Components

Electrical and electromechanical components of the Variable Frequency  
Drive (VFD) shall not cause electromagnetic interference to adjacent  
electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

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

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified shall be protected against surges induced on  
control and sensor wiring installed outdoors and as shown. The inputs and  
outputs shall be tested 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.

#### 1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

Submit drawings for government approval prior to equipment construction or integration. Modifications to original drawings made during installation shall be immediately recorded for inclusion into the as-built drawings.

##### SD-03 Product Data

Variable Frequency Drives; G

Wires and Cables

Equipment Schedule

Include data indicating compatibility with motors being driven.

##### SD-06 Test Reports

VFD Test

Performance Verification Tests

Endurance Test

##### SD-08 Manufacturer's Instructions

Installation instructions

##### SD-09 Manufacturer's Field Reports

VFD Factory Test Plan; G

Factory test results

##### SD-10 Operation and Maintenance Data

Variable Frequency Drives, Data Package 4

Submit 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. Submit 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.

## 1.5 QUALITY ASSURANCE

### 1.5.1 Schematic Diagrams

Show 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.

### 1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

### 1.5.3 Installation Drawings

Show floor plan of each site, with VFDs and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes.

### 1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule shall provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule shall include the total quantity of each item of equipment supplied. For complete assemblies, such as VFDs, 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.

### 1.5.5 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.

### 1.5.6 Factory Test Results

Document test results and submit to government within 7 working days after completion of test.

## 1.6 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.



## 1.7 WARRANTY

The complete system shall be warranted by the manufacturer for a period of one year, or the contracted period of any extended warrantee agreed upon by the contractor and the Government, after successful completion of the acceptance test. Any component failing to perform its function as specified and documented shall be repaired or replaced by the Contractor at no additional cost to the Government. Items repaired or replaced shall 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.

## 1.8 MAINTENANCE

### 1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

### 1.8.2 Maintenance Support

During the warranty period, the Contractor shall provide on-site, on-call maintenance services by Contractor's personnel on the following basis: The service shall be on a per-call basis with 36 hour response. Contractor shall support the maintenance of all hardware and software of the system. Various personnel of different expertise shall be sent on-site depending on the nature of the maintenance service required. Costs shall 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, shall be borne by the Contractor.

## PART 2 PRODUCTS

### 2.1 VARIABLE FREQUENCY DRIVES (VFD)

Provide frequency drive to control the speed of induction motor(s). The VFD shall 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 508C** shall change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter shall utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter shall be insensitive to three phase rotation of the ac line and shall not cause displacement power factor of less than .95 lagging under any speed and load condition.
- c. An inverter stage shall change fixed dc voltage to variable frequency, variable voltage, ac for application to a standard NEMA design B squirrel cage motor. The inverter shall be switched in a manner to produce a sine coded pulse width modulated (PWM) output waveform.

- d. The VFD shall be capable of supplying 120 percent of rated full load current for one minute at maximum ambient temperature.
- e. The VFD shall be designed to operate from a 480 volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.
- f. Acceleration and deceleration time shall be independently adjustable from one second to 60 seconds.
- g. Adjustable full-time current limiting shall limit the current to a preset value which shall not exceed 120 percent of the controller rated current. The current limiting action shall maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override shall allow starting current to reach 175 percent of controller rated current to maximum starting torque.
- h. The controllers shall 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 shall be included such that a failure in the controller electronic circuitry shall not cause frequency to exceed 110 percent of the maximum controller output frequency selected.
- i. Minimum and maximum output frequency shall 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 shall not be less than 96 percent.
- k. The controllers shall be capable of being restarted into a motor coasting in the forward direction without tripping.
- l. Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions shall 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 shall be included such that current exceeding an adjustable threshold shall activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.
- n. A slip compensation circuit shall be included which will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA B motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.
- o. The VFD shall 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 VFD shall 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 VFD shall include external fault reset capability. All the necessary logic to accept an external fault reset contact shall be included.
- q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The VFD shall have a minimum of three user selectable bandwidths.
- r. Provide the following operator control and monitoring devices mounted on the front panel of the VFD:
  - (1) Manual speed potentiometer.
  - (2) Hand-Off-Auto (HOA) switch.
  - (3) Power on light.
  - (4) Drive run power light.
  - (5) Local display.
- s. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of VFD failure. Mechanical and electrical interlocks shall be installed between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer.

## 2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, NEMA ICS 6.

## 2.3 WIRES AND CABLES

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

## 2.4 NAMEPLATES

Nameplates external to NEMA enclosures shall conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEMS. Nameplates internal to enclosures shall be manufacturer's standard, with the exception that they must be permanent.

## 2.5 SOURCE QUALITY CONTROL

### 2.5.1 VFD Factory Test Plan

To ensure quality, each VFD shall be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans and 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 shall supervise the installation of all equipment, and wiring.

### 3.2 FIELD QUALITY CONTROL

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

#### 3.2.1 VFD Test

A proposed test plan shall be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests shall conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. The contractor shall inform the Government at least 14 working days prior to the dates of testing. Contractor shall provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. 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.

#### 3.2.2 Performance Verification Tests

"Performance Verification Test" plan shall provide the step by step procedure required to establish formal verification of the performance of the VFD. Compliance with the specification requirements shall 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. The contractor shall inform the Government 14 calendar days

prior to the date the test is to be conducted.

### 3.2.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test shall commence. The system shall be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of .9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. During the endurance test, the contractor shall not be allowed in the building. The system shall respond as designed.

## 3.3 DEMONSTRATION

### 3.3.1 Training

Coordinate training requirements with the Contracting Officer.

#### 3.3.1.1 Instructions to Government Personnel

Provide the services of competent instructors 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 shall be thoroughly familiar with the subject matter they are to teach. The Government personnel designated to attend the training will have a high school education or equivalent. The number of training days of instruction furnished shall 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 shall be turned over to the Government at the end of last training session.

#### 3.3.1.2 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

### 3.3.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training shall be conducted on site at a location designated by the Government. Provide a one-day training session to train 4 engineering personnel in the functional operations of the system. This training shall 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** (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
National Electrical Code

**NFPA 780** (2020) Standard for the Installation of Lightning Protection Systems

##### UNDERWRITERS LABORATORIES (UL)

**UL 96** (2016a) UL Standard for Safety Lightning Protection Components

**UL 467** (2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment

**UL Electrical Constructn** (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 before making any departures from the design.

###### 1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with **NFPA 70**, **NFPA 780**, and **UL 96**.

###### 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

Overall lightning protection system; G

Each major component

#### SD-06 Test Reports

Lightning Protection and Grounding System Test Plan

Lightning Protection and Grounding System Test; G

#### SD-07 Certificates

Lightning Protection System Installers Documentation

Component UL Listed and Labeled

Lightning protection system inspection certificate; G

Roof manufacturer's warranty

### 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 in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

#### 1.4.1 Installation Drawings

##### 1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.

##### 1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's



descriptive and technical literature, catalog cuts, and installation instructions.

#### 1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in [UL Electrical Constructn](#), 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.

#### 1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) 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. 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 specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

#### 1.4.4 Lightning Protection System Inspection Certificate

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

### 1.5 SITE CONDITIONS

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 before changing the design.

## PART 2 PRODUCTS

### 2.1 MATERIALS

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

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

#### 2.1.2 Copper Only

Provide copper conductors, except where aluminum conductors are required for connection to aluminum equipment.

### 2.2 COMPONENTS

#### 2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. 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 made of copper-clad steel conforming to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 10 feet in length. Do not mix ground rods of copper-clad steel or 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 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.

### PART 3 EXECUTION

#### 3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780, including tie-ins to existing lightning protection systems. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, and grounding electrodes and ground ring electrode conductor. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

##### 3.1.1 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.

#### 3.1.1.1 Air Terminals

Use a standing seam base for installation of air terminals on a standing seam metal roof that does not produce any roof penetrations.

#### 3.1.1.2 Roof Conductors

Use a standing seam base for installation of roof conductors on a standing seam metal roof that does not produce any roof penetrations.

#### 3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by [NFPA 780](#). Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC. Down conductors are to be concealed within the wall cavities.

#### 3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

#### 3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less [10 feet](#). Set ground rods not less than [3 feet](#) nor more than [8 feet](#), from the structure foundation, and at least 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 driven ground rod is 5 ohms, under normally dry conditions. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than [10 feet](#) into the ground, a minimum of [10 feet](#) apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. 4/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than [3 feet](#) nor more than [8 feet](#) from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of [30 inches](#). Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

#### 3.1.5 Grounding Plates

Provide a grounding plate below each IG room raised floor. Connect and ground the raised floor and supports. The grounding plate will contain a quantity of 10, 7/16 inch diameter mounting holes with lugs attached to accept from 14 to 2 AWG wire size. The lugs shall be removable for access to the 7/16 inch diameter holes for alternate wire installation.

### 3.2 APPLICATIONS

#### 3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least 3 square inches.

### 3.3 RESTORATION

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

### 3.4 FIELD QUALITY CONTROL

#### 3.4.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 5 ohms. Provide documentation for the measured values at each test point. 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, 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 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 in the text by the basic designation only.

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

ASHRAE 90.1 - IP (2013) Energy Standard for Buildings  
Except Low-Rise Residential Buildings

ASHRAE 189.1 (2018) Standard for the Design of  
High-Performance Green Buildings Except  
Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M (2018) Standard Specification for  
Stainless Steel Wire

ASTM A641/A641M (2019) Standard Specification for  
Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM A653/A653M (2019) Standard Specification for Steel  
Sheet, Zinc-Coated (Galvanized) or  
Zinc-Iron Alloy-Coated (Galvannealed) by  
the Hot-Dip Process

ASTM A1008/A1008M (2016) 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 (2015/2019) 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

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24 (2016) Building Energy Efficiency

Standards For Residential and  
Nonresidential Buildings

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011; Errata 2015) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80	(2015) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2010; Addendum A 2008; Addenda B 2009; Addendum C 2016) Nomenclature and Definitions for Illuminating Engineering
IES TM-21	(2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) 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	(2018) 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	(2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA SSL 1	(2010) Electronic Drivers for Led Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination

NEMA SSL 7A (2015) Phase-Cut Dimming for Solid State Lighting: Basic Compatibility

NEMA WD 1 (1999; R 2015) Standard for General Color Requirements for Wiring Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
National Electrical Code

NFPA 101 (2018; TIA 18-1; TIA 18-2; TIA 18-3) Life Safety Code

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8500.01 (2014) Cybersecurity

DOD 8510.01 (2014; Change 1-2016; Change 2-2017) Risk Management Framework (RMF) for DoD Information Technology (IT)

UNDERWRITERS LABORATORIES (UL)

UL 20 (2010; Reprint Feb 2012) General-Use Snap Switches

UL 94 (2013; Reprint Sep 2017) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 508 (2018) UL Standard for Safety Industrial Control Equipment

UL 916 (2007; Reprint Aug 2014) Standard for Energy Management Equipment

UL 917 (2006; Reprint Aug 2013) UL Standard for Safety Clock-Operated Switches

UL 924 (2016; Reprint May 2018) UL Standard for Safety Emergency Lighting and Power Equipment

UL 1472 (2015) UL Standard for Safety Solid-State Dimming Controls

UL 1598 (2008; Reprint Oct 2012) Luminaires

UL 2043 (2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces

UL 8750 (2015; Reprint Aug 2018) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

## 1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires or luminaire accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories mounted on exterior surfaces of buildings are specified in Section 26 56 00 EXTERIOR LIGHTING.

## 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 IES RP-16.
- b. For fluorescent, HID and induction luminaire light sources, "Average Rated Life" is the time after which 50 percent of a large group of light sources will have failed and 50 percent will have survived under normal conditions.
- c. 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 IES LM-80.
- d. For fluorescent, HID and induction luminaires, "Luminaire Efficacy Rating" (LER) is the appropriate measure of energy efficiency, measured in lumens/watt. Specifically it is the luminaire's efficiency multiplied by the total rated light source lumens and the ballast factor, divided by the luminaire input watts.
- e. 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.
- f. 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES HB-10 as applicable, for the lighting system specified. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings

Occupancy/Vacancy Sensor Coverage Layout

SD-03 Product Data



Luminaires; G

Light Sources

Drivers, Ballasts and Generators

LED Luminaire Warranty; G

Luminaire Design Data

Vacancy Sensors

Dimming Controllers (Dimmers)

Lighting Contactor

Timeswitch

Exit Signs; G

LED Emergency Drivers

Occupancy Sensors

Ambient Light Level Sensor

Lighting Control Panel; G

#### SD-06 Test Reports

LED Luminaire - IES LM-79 Test Report

LED Light Source - IES LM-80 Test Report

LED Light Source - IES TM-21 Test Report

Occupancy/Vacancy Sensor Verification Tests

Energy Efficiency; S

#### SD-07 Certificates

Luminaire Useful Life Certificate

LED Driver and Dimming Switch Compatibility Certificate

### 1.5 QUALITY CONTROL

#### 1.5.1 Luminaire Drawings

Include dimensions, accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data must accompany shop drawings.

#### 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 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices.

#### 1.5.4 Luminaire Design Data

- a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified per the **NFPA 70** (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).
- b. Provide long term lumen maintenance projections for each LED luminaire in accordance with **IES TM-21**. Data used for projections must be obtained from testing in accordance with **IES LM-80**.

#### 1.5.5 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in **IES LM-79**.

#### 1.5.6 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module). Include all applicable and required data as outlined under "8.0 Test Report" in **IES LM-80**.

#### 1.5.7 LED Light Source - IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module). Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in **IES TM-21**.

#### 1.5.8 Occupancy/Vacancy Sensor Verification Tests

Submit test report outlining post-installation coverage and operation of sensors.

#### 1.5.9 Test Laboratories

Test laboratories for the **IES LM-79** and **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 at for LM-79 testing.
- c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

#### 1.5.10 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 NFPA 70, unless more stringent requirements are specified or indicated.

#### 1.5.11 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 two years prior to bid opening. The two-year 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 two-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.

##### 1.5.11.1 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.

##### 1.5.11.2 Material and Equipment Manufacturing Date

Products manufactured more than six months prior to date of delivery to site must not be used, unless specified otherwise.

##### 1.5.11.3 Energy Efficiency

Submit data indicating lumens per watt efficacy and color rendering index of light source.

#### 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 LED Luminaire Warranty

- a. Provide a written 10 year onsite replacement warranty for material, fixture finish, and workmanship. Onsite replacement includes transportation, removal, and installation of new products.

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

(2) Material warranty must include:

(a) All drivers.

(b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

b. Warranty period must begin on date of beneficial occupancy. Provide the Contracting Officer with signed warranty certificates prior to final payment.

#### 1.6.1.1 Provide Luminaire Useful Life Certificate

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life must be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions must be taken into consideration.

## PART 2 PRODUCTS

### 2.1 PRODUCT COORDINATION

Products and materials not considered to be luminaires, luminaire controls, or associated equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires, luminaire controls, and associated equipment for exterior applications are specified in Section 26 56 00 EXTERIOR LIGHTING.

### 2.2 LUMINAIRES

UL 1598, NEMA C82.77, and UL 8750. Provide luminaires as indicated in luminaire schedule and NL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. Provide all luminaires of the same type by the same manufacturer. Luminaires must be specifically designed for use with the driver, ballast or generator and light source provided.

#### 2.2.1 LED Luminaires

Provide luminaires complete with power supplies (drivers) and light sources. Provide design information including lumen output and design life in luminaire schedule on project plans for LED luminaires. LED luminaires must meet the minimum requirements in the following table:

LUMINAIRE TYPE	MINIMUM LUMINAIRE EFFICACY (LE)	MINIMUM COLOR RENDERING INDEX (CRI)
LED TROFFER - 1 x 4 2 x 2 2 x 4	90 LPW	80
LED Downlight	50 LPW	90
LED Track or Accent	40 LPW	80
LED Low Bay/High Bay	80 LPW	70

<u>LUMINAIRE TYPE</u>	<u>MINIMUM LUMINAIRE EFFICACY (LE)</u>	<u>MINIMUM COLOR RENDERING INDEX (CRI)</u>
LED Linear Ambient	80 LPW	80

LED luminaires must also meet the following minimum requirements:

- a. Luminaires must have a minimum 10 year manufacturer's warranty.
- b. Luminaires must have a minimum L70 lumen maintenance value of 50,000 hours as calculated by **IES TM-21**, with data obtained per **IES LM-80** requirements.
- c. Luminaire drive current value must be identical to that provided by test data for luminaire in question.
- d. Luminaires must be tested to **IES LM-79** and **IES LM-80** standards, with the results provided as required in the Submittals paragraph of this specification.
- e. Luminaires must be listed with the DesignLights Consortium 'Qualified Products List' when falling into category of "General Application" luminaires, i.e. Interior Directional, Display Case, Troffer, Linear Ambient, or Low/High Bay. Requirements are shown in the DesignLights Consortium "Technical Requirements Table" at <https://data.energystar.gov/dataset/EPA-Recognized-Laboratories-For-Lighting-Products/jgwf-7qrr>.
- f. Provide Department of Energy 'Lighting Facts' label for each luminaire.

## 2.3 DRIVERS, BALLASTS and GENERATORS

### 2.3.1 LED Drivers

**NEMA SSL 1**, **UL 8750**. LED drivers must be electronic, UL Class 1, constant-current type and comply with the following requirements:

- a. Output power (watts) and luminous flux (lumens) as shown in luminaire schedule for each luminaire type to meet minimum luminaire efficacy (LE) value provided.
- b. Power Factor (PF) greater than or equal to 0.9 over the full dimming range when provided.
- c. Current draw Total Harmonic Distortion (THD) of less than 20 percent.
- d. Class A sound rating.
- e. Operable at input voltage of 120-277 volts at 60 hertz.
- f. Minimum 5 year manufacturer's warranty.
- g. RoHS compliant.
- h. Integral thermal protection that reduces or eliminates the output power if case temperature exceeds a value detrimental to the driver.
- i. UL listed for dry or damp locations typical of interior installations.

- j. Or fully-dimmable using 0-10V control as indicated in luminaire schedule.

## 2.4 LIGHT SOURCES

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

## 2.5 LIGHTING CONTROLS

ASHRAE 90.1 - IP ASHRAE 189.1. Provide network certification for all networked lighting control systems and devices per requirements of DOD 8500.01 and DOD 8510.01.

### 2.5.1 Toggle Switches

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

### 2.5.2 Dimming Controllers (Dimmers)

UL 1472, UL 20, IEEE C62.41, NEMA SSL 7A. 120/277 V0-10 V dimmers must provide flicker-free, continuously variable light output throughout the dimming range. Provide radio frequency interference suppression integral to device. Provide dimmers utilizing constant current reduction (CCR) technology. Provide device with a vertical slider, paddle, rotary button, or toggle (with adjacent vertical slider) type control, with finish to match switches and outlets in same area. Provide back box in wall with sufficient depth to accommodate body of switch and wiring. Devices must be capable of operating at their full rated capacity regardless of being single or ganged-mounted and be compatible with three-way and four-way switching scenarios. Dimmers must be capable of controlling 0-10 volt fluorescent ballasts or LED drivers. Ensure compatibility of dimmer with separate power packs when utilized for lighting control. Dimmers and the ballasts or drivers they control, must be provided from the same manufacturer, or tested and certified as compatible for use together. Provide NEMA SSL 7A-compliant devices.

### 2.5.3 Sensors for Lighting Control

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A.

#### 2.5.3.1 Occupancy Sensors

Provide occupancy sensors with coverage patterns as indicated on project plans. Provide no less quantity of sensors as shown on plans but add additional sensors when required to fulfill coverage requirement for the specific model sensor provided. Sensor must be provided with an adaptive learning function that automatically sets sensor in optimum calibration in a set period of time after installation and a non-volatile memory that saves settings after a power outage. Provide sensors designed for ceiling, wall or wall-box installation as indicated. Operating voltage must be 277 volts. Operating voltage must be 24V in conjunction with a control system or separate power pack which interacts with luminaire being controlled. Provide housing of high-impact, injection-molded thermoplastic with a multi-segmented lens for PIR and dual technology sensors. Sensor operation requires movement to activate luminaires controlled and turns luminaires off after a set time of inactivity.

#### 2.5.3.1.1 Dual Technology Sensors

Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the passive infrared or ultrasonic sensing registers occupancy, the luminaires must remain on.

#### 2.5.3.1.2 High/Low-Bay Sensors

Provide occupancy sensors specifically designed for high/low-bay mounting application using passive infrared (PIR) technology, with the following characteristics:

- a. Input voltage of 120/277 volts, at 50/60 hertz.
- b. High-impact, injection-molded thermoplastic housing with interchangeable lenses for 360 degree open area coverage or narrow rectangular, warehouse aisle coverage.
- c. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.
- d. Be designed to mount directly to or adjacent to high or low-bay luminaires.
- e. UL listed, CEC Title 24 and ASHRAE 90.1 - IP compliant.

#### 2.5.3.1.3 Power Packs for Sensors

UL 2043, CEC Title 24, ASHRAE 90.1 - IP. Power packs used to provide power to one or more lighting control sensors must meet the following requirements:

- a. Input voltage - 120-277 VAC; output voltage - 24 VDC at 225 mA.
- b. Plenum-rated, high-impact thermoplastic enclosure.
- c. Utilizes zero-crossing circuitry to prevent damage from inrush current.
- d. Maximum load rating of 16 amps for electronic lighting loads.
- e. RoHS compliant.

#### 2.5.3.2 Vacancy Sensors

Provide vacancy sensors as indicated above under paragraph OCCUPANCY SENSORS, but with requirement of a manual operation to activate luminaires controlled. Provide automatic operation to turn luminaires off after a set period of inactivity.

#### 2.5.4 Lighting Contactor

NEMA ICS 2. Provide an electrically-held lighting contactor housed in a NEMA 1 and 3R enclosure conforming to NEMA ICS 6. Provide contactor with one normally-open (NO), single pole contacts, rated 600 volts, 30 amps. Provide coil operating voltage of 277 volts.

#### 2.5.5 Timeswitch

UL 917. Provide electromechanical type timeswitch with a 24 hour and

7-day astronomic dial. Provide power to switch from integral synchronous motor with a maximum three-watt rating. Rate contacts at 40 amps at 120-277 volts for general purpose loads. Provide contacts in a SPST, normally-open (NO) configuration. Provide switch with manual bypass remote override control function.

Provide electronic type time-switch with a 24 hour, 7 day astronomic programming function, providing a total of 56 on/off set points. Provide 24 hour type digital clock display format. Provide power outage back-up for switch for a minimum of 3 days. Provide switch capable of controlling a minimum of 2 channels or loads. Rate contacts at 30 amps at 120/277 volts for general purpose loads. Provide contacts in a SPST, normally-open (NO) configuration. Provide switch with manual bypass or remote override control momentary function for output contacts. Provide with occupancy sensor input control.

House timeswitch in a surface-mounted, lockable, NEMA 1 enclosure constructed of painted steel or plastic polymer conforming to NEMA ICS 6.

#### 2.5.6 Lighting Control Panel

Provide an electronic, programmable lighting control panel, capable of providing lighting control with input from internal programming, digital switches, time clocks, and other low-voltage control devices.

Enclose panel hardware in a surface-mounted, NEMA 1, painted, steel enclosure, with hinged, lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door.

Input voltage - 120/277 V, 60 Hz, with internal 24 VDC power supply.

Provide 8 single-pole latching relays rated at 30 amps, 120 volts.

Relay control module must operate at 24 VDC and be rated to control a minimum of 8 relays.

#### 2.5.7 Local Area Lighting Controller

CEC Title 24 and ASHRAE 90.1 - IP compliant. Provide controller designed for single area or room with the following requirements:

- a. 277 volt input, designed for fluorescent or LED lighting loads.
- b. 2 zone, with 2 relays rated 20 amps each.
- c. Provide daylight harvesting capability with full-range dimming control.
- d. Inputs for occupancy sensor, photocell, and low-voltage wall switch.
- e. Provide capability for receptacle load control.
- f. Provide full 'OFF' function with input from external time clock input.

#### 2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

UL 924, NFPA 101, and NFPA 70 compliant.



## 2.6.1 Exit Signs

Provide exit signs consuming a maximum of five watts total.

### 2.6.1.1 LED Self-Powered Exit Signs

Provide in die-cast brushed aluminum housing configured for ceiling, wall, end mounting. Provide edge-lit type with clear acrylic, edge-lit face and aluminum trim having clear aluminum white finish. Match existing Phase 1. Provide 6 inch high, 3/4 inch stroke red lettering on face of sign. Provide chevrons on either side of lettering to indicate direction. Provide single or double face as indicated. 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.

## 2.6.2 LED Emergency Drivers

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 10 watts, 10-50 VDC compatible with LED forward voltage requirements, 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 and Fluorescent Emergency Drivers/Ballasts

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 SUPPORT HARDWARE

### 2.7.1 Wire

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

### 2.7.2 Wire for Humid Spaces

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

ASTM B164; UNS NO4400, annealed nickel-copper alloy, minimum 0.11 inches in diameter.

### 2.7.3 Threaded Rods

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

### 2.7.4 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 POWER HOOK LUMINAIRE HANGERS

UL 1598 Provide an assembly consisting of through-wired power hook housing, interlocking plug and receptacle, power cord, and luminaire support loop. Power hook housing must be cast aluminum having two 3/4 inch threaded hubs. Support hook must have safety screw. Fixture support loop must be cast aluminum with provisions for accepting 3/4 inch threaded stems. Power cord must include 16 inches of 3 conductor No. 16 Type SO cord. Assembly must be rated 120 volts or 277 volts, 15 amperes.

## 2.9 EQUIPMENT IDENTIFICATION

### 2.9.1 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.

### 2.9.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires must be clearly marked for operation of specific light sources and ballasts, generators or drivers. Note the following light source characteristics in the format "Use Only \_\_\_\_\_":

- a. Light source diameter code (T-4, T-5, T-8), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
- b. Light source type, wattage, envelope type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
- c. Start type (programmed start, instant start) for fluorescent and compact fluorescent luminaires.
- d. ANSI ballast type (M98, M57, etc.) for HID luminaires.
- e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

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. Ballasts, generators or drivers must have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

## 2.10 FACTORY APPLIED FINISH

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

## 2.11 RECESS- AND FLUSH-MOUNTED LUMINAIRES

Provide access to lamp and ballast from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications.

## 2.12 SUSPENDED LUMINAIRES

Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers. Provide with swivel hangers to ensure a plumb installation. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers must allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended luminaires must have twin-stem hangers. Multiple-unit or continuous row luminaires 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. Provide rods in minimum 0.18 inch diameter.

# PART 3 EXECUTION

## 3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein. Install luminaires and lighting controls to meet the requirements of ASHRAE 90.1 - IP and ASHRAE 189.1. To encourage consistency and uniformity, install luminaires of the same manufacture and model number when residing in the same facility or building.

### 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, color rendering index, 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. Installation must meet requirements of NFPA 70. Mounting heights specified or indicated must be to the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain 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. Recessed and semi-recessed luminaires must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire and located near each corner of the luminaire. Ceiling grid clips are not allowed as an alternative to independently supported luminaires. Round luminaires or luminaires

smaller in size than the ceiling grid must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around. Do not support luminaires by acoustical tile ceiling panels. 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. Provide wires, straps, or rods for luminaire support in this section. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

### 3.1.3 Suspended Luminaires

Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level. Locate so that there are no obstructions within the 45 degree range in all directions. The stem, canopy and luminaire must be capable of 45 degree swing. Pendants, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation. 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. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints. Support steel luminaires to prevent "oil-canning" effects. Luminaire finishes must be free of scratches, nicks, dents, and warps, and must match the color and gloss specified. Match supporting pendants with supported luminaire. Aircraft cable must be stainless steel. Canopies must be finished to match the ceiling and must be low profile unless otherwise shown. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

### 3.1.4 Ballasts, Generators and Power Supplies

Typically, provide ballasts, generators, and power supplies (drivers) integral to luminaire as constructed by the manufacturer.

### 3.1.5 Exit Signs and Emergency Lighting Units

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

### 3.1.6 Occupancy/Vacancy Sensors

Provide testing of sensor coverage in all spaces where sensors are placed. This should be done only after all furnishings (carpet, furniture, workstations, etc.) have been installed. 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. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage.

### 3.1.7 Daylight or Ambient Light Level Sensor

Locate sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for 30 foot-candles or for the indicated

light level measured at the work plane for that particular area.

### 3.2 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.

-- End of Section --

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SECTION 26 56 00

EXTERIOR 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 in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS  
(AASHTO)

AASHTO LTS (2013; Errata 2013) Standard  
Specifications for Structural Supports for  
Highway Signs, Luminaires and Traffic  
Signals

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M (2016) Standard Specification for Zinc  
Coating (Hot-Dip) on Iron and Steel  
Hardware

ASTM B108/B108M (2015) Standard Specification for  
Aluminum-Alloy Permanent Mold Castings

ASTM B117 (2016) Standard Practice for Operating  
Salt Spray (Fog) Apparatus

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10 (2011; Errata 2015) IES Lighting Handbook

IES LM-79 (2008) Electrical and Photometric  
Measurements of Solid-State Lighting  
Products

IES LM-80 (2015) Measuring Lumen Maintenance of LED  
Light Sources

IES RP-8 (2014/2018) Recommended Practice for  
Lighting Roadway Lighting and Parking  
Facilities

IES RP-16 (2010; Addendum A 2008; Addenda B 2009;  
Addendum C 2016) Nomenclature and  
Definitions for Illuminating Engineering

IES TM-15 (2011) Luminaire Classification System for  
Outdoor Luminaires

IES TM-21 (2011; Addendum B 2015) Projecting Long  
Term Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
- IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
- 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)

- ANSI C136.3 (2014) American National Standard for Roadway and Area Lighting Equipment Luminaire Attachments
- ANSI C136.13 (2004; R 2009) American National Standard for Roadway Lighting Equipment, Metal Brackets for Wood Poles
- ANSI C136.21 (2014) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
- NEMA 250 (2018) 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 (2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
- NEMA C136.10 (2017) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
- NEMA C136.31 (2018) Roadway and Area Lighting Equipment - Luminaire Vibration
- NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
- NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures
- NEMA IEC 60529 (2004) Degrees of Protection Provided by Enclosures (IP Code)



NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star (1992; R 2006) Energy Star Energy  
Efficiency Labeling System (FEMP)

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

47 CFR 15 Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 773 (2016; Reprint Nov 2017) UL Standard for  
Safety Plug-In, Locking Type Photocontrols  
for Use with Area Lighting

UL 773A (2016; Reprint May 2018) UL Standard for  
Safety Nonindustrial Photoelectric  
Switches for Lighting Control

UL 1310 (2018) UL Standard for Safety Class 2  
Power Units

UL 1598 (2008; Reprint Oct 2012) Luminaires

UL 8750 (2015; Reprint Aug 2018) UL Standard for  
Safety Light Emitting Diode (LED)  
Equipment for Use in Lighting Products

## 1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires or lighting equipment are specified in Section(s) 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Luminaires and accessories installed in interior of buildings are specified in Section 26 51 00 INTERIOR LIGHTING.

## 1.3 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings shall be as defined in IEEE 100 and IES RP-16.
- 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 IES LM-80.

## 1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control

approval. 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

Photometric Plan; G

LED Luminaire Warranty; G, S

SD-02 Shop Drawings

Luminaire Drawings

Poles

SD-03 Product Data

LED Luminaires; G

Energy Star Label for LED Luminaire Product; S

Luminaire Light Sources

Luminaire Power Supply Units (Drivers)

Lighting Contactor

Time Switch

Photocell

Aluminum Poles; G

Brackets

SD-05 Design Data

Design Data for Luminaires

SD-06 Test Reports

LED Luminaire - IES LM-79 Test Report

LED Light Source - IES LM-80 Test Report

Submit operating test results as stated in paragraph entitled "Field Quality Control."

SD-07 Certificates

Luminaire Useful Life Certificate

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life shall be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions

shall be taken into consideration.

#### SD-10 Operation and Maintenance Data

##### Electronic Ballast Warranty

##### Operational Service

Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

### 1.5 QUALITY ASSURANCE

#### 1.5.1 Drawing Requirements

##### 1.5.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and candlepower distribution data shall accompany shop drawings.

##### 1.5.1.2 Poles

Include dimensions, wind load determined in accordance with **AASHTO LTS**, pole deflection, pole class, and other applicable information.

#### 1.5.2 Photometric Plan

For LED luminaires, include computer-generated photometric analysis of the "designed to" values for the "end of useful life" of the luminaire installation using a light loss factor of 0.7. For LED and all other types of luminaires, the submittal shall include the following:

Horizontal illuminance measurements at finished grade, taken at a maximum of every **10 feet**.

Vertical illuminance measurements at **5 feet** above finished grade.

Minimum and maximum **footcandle** levels.

Average maintained **footcandle** level.

Maximum to minimum ratio for horizontal illuminance only.

#### 1.5.3 Design Data for Luminaires

- a. Provide distribution data according to IES classification type as defined in **IES HB-10**.
- b. Shielding as defined by **IES RP-8** or B.U.G. rating for the installed position as defined by **IES TM-15**.
- c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification per **NFPA 70** (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally

Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

- d. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections shall be obtained from testing in accordance with IES LM-80.
- e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets shall not exceed maximum rating of pole as installed in particular wind zone area.

#### 1.5.4 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Submittal shall include all photometric and electrical measurements, as well as all other pertinent data outlined under "14.0 Test Report" in IES LM-79.

#### 1.5.5 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED package, array, or module. Submittal shall include:

- a. Testing agency, report number, date, type of equipment, and LED light source being tested.
- b. All data required by IES LM-80.

##### 1.5.5.1 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports shall 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.
- b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.
- c. A manufacturer's in-house lab that meets the following criteria:
  - 1. Manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires and the manufacturer's lab has been successfully certifying these fixtures for a minimum of 15 years.
  - 2. Annual equipment calibration including photometer calibration in accordance with National Institute of Standards and Technology.

#### 1.5.6 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.

#### 1.5.7 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.

##### 1.5.7.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires for a minimum of 15 years. Products shall have been in satisfactory commercial or industrial use for 15 years prior to bid opening. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 15-year period.

##### 1.5.7.2 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.

#### 1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

##### 1.6.1 Aluminum Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

#### 1.7 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.

##### 1.7.1 LED Luminaire Warranty

Provide Luminaire Useful Life Certificate.

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.

- a. Provide a written five year on-site replacement warranty for material,

fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

1. Finish warranty shall include warranty against failure and against substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

2. Material warranty shall include:

- (a) All power supply units (drivers).

- (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

- b. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the Contracting Officer signed warranty certificates prior to final payment.

#### 1.7.2 Electronic Ballast Warranty

Furnish the electronic ballasts manufacturer's warranty. The warranty period shall not be less than five (5) years from the date of manufacture. Ballast assembly in the lighting fixture, transportation, and onsite storage shall not exceed twelve (12) months, thereby permitting four (4) years of the five (5) year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

#### 1.8 OPERATIONAL SERVICE

Coordinate with manufacturer for maintenance agreement or take-back program. Collect information from the manufacturer about maintenance agreement options and submit to Contracting Officer. Services shall reclaim materials for recycling and/or reuse. Services shall not deposit materials in landfills or burn reclaimed materials. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, local recyclers shall be sought after to reclaim the materials.

### PART 2 PRODUCTS

#### 2.1 PRODUCT COORDINATION

Products and materials not considered to be luminaires, equipment or accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and associated equipment and accessories for interior applications are specified in Section 26 51 00 INTERIOR LIGHTING.

#### 2.2 LED LUMINAIRES

UL 1598, NEMA C82.77 and UL 8750. Provide luminaires as indicated in luminaire schedule and XL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. All luminaires of the same type shall be provided by the same manufacturer. Provide Energy Star labeled LED luminaire product. Provide proof of Energy Star label for LED luminaire product.

### 2.2.1 General Requirements

- a. LED luminaire housings shall be die cast or extruded aluminum.
- b. LED luminaires shall be rated for operation within an ambient temperature range of **minus 22 degrees F** to **104 degrees F**.
- c. Luminaires shall be UL listed for wet locations per **UL 1598**. Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per **NEMA IEC 60529**.
- d. LED luminaires shall produce a minimum efficacy as shown in the following table, tested per **IES LM-79**. Theoretical models of initial raw LED lumens per watt are not acceptable.

Application	Luminaire Efficacy in Lumens per Watt
Exterior Pole/Arm-Mounted Area and Roadway Luminaires	65
Exterior Pole/Arm-Mounted Decorative Luminaires	65
Exterior Wall-Mounted Area Luminaires	60

- e. Luminaires shall have IES distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans per **IES HB-10**.
- f. Housing finish shall be baked-on enamel, anodized, or baked-on powder coat paint. Finish shall be capable of surviving **ASTM B117** salt fog environment testing for 2500 hours minimum without blistering or peeling.
- g. Luminaires shall not exceed the following **IES TM-15** Backlight, Uplight and Glare (B.U.G.) ratings:
  1. Maximum Backlight (B) rating shall be determined by lighting zone in which luminaire is placed.
  2. Maximum Uplight (U) rating shall be U0.
  3. Maximum Glare (G) rating shall be determined by lighting zone in which luminaire is placed.
- h. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.
- i. The finish color shall be as indicated in the luminaire schedule or detail on the project plans.
- j. Luminaire lenses shall be constructed of clear tempered glass or UV-resistant acrylic.
- k. The wiring compartment on pole-mounted, street and area luminaires must be accessible without the use of hand tools to manipulate small

screws, bolts, or hardware.

- l. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, power supply units, ballasts, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.
- m. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.
- n. Luminaire must pass 3G vibration testing in accordance with [NEMA C136.31](#).
- o. All factory electrical connections shall be made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

## 2.2.2 Luminaire Light Sources

### 2.2.2.1 LED Light Sources

- a. Correlated Color Temperature (CCT) shall be in accordance with [NEMA ANSLG C78.377](#):

Nominal CCT: 4000 degrees K: 3985 plus or minus 275 degrees K

- b. Color Rendering Index (CRI) shall be:

Greater than or equal to 70 for 4000 degrees K light sources.

- c. Color Consistency:

Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

### 2.2.3 Luminaire Power Supply Units (Drivers)

#### 2.2.3.1 LED Power Supply Units (Drivers)

[UL 1310](#). LED Power Supply Units (Drivers) shall meet the following requirements:

- a. Minimum efficiency shall be 85 percent.
- b. Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent.
- c. Shall be rated to operate between ambient temperatures of [minus 22 degrees F](#) and [104 degrees F](#).
- d. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.
- e. Operating frequency shall be: 50 or 60 Hz.
- f. Power Factor (PF) shall be greater than or equal to 0.90.



- g. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.
- h. Shall meet requirements of 47 CFR 15, Class B.
- i. Shall be RoHS-compliant.
- j. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.
- k. Power supplies in luminaires mounted under a covered structure, such as a canopy, or where otherwise appropriate shall be UL listed with a sound rating of A.
- l. Shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system.
- m. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

#### 2.2.4 LED Luminaire Surge Protection

Provide surge protection integral to luminaire to meet C Low waveforms as defined by IEEE C62.41.2, Scenario 1, Location Category C.

### 2.3 EXTERIOR LUMINAIRE CONTROLS

#### 2.3.1 Photocell

UL 773 or UL 773A. Photocells shall be hermetically sealed, silicon diode light sensor type, rated at 10 watts, 480 volts, 50/60 Hz with single-pole, double-throw contacts. Photocell shall be designed to fail to the ON position. Housing shall be constructed of die cast aluminum or UV stabilized polypropylene, rated to operate within a temperature range of minus 40 to 158 degrees F. Photocell shall have a 1/2 in threaded base for mounting to a junction box or conduit. Provide swivel base type housing. Photocell shall be twist-lock receptacle type conforming to NEMA C136.10. Provide with solid brass prongs and voltage markings and color coding on exterior of housing. Photocell shall turn on at 1-3 footcandles and turn off at 3 to 15 footcandles. A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition. Provide photocell with metal oxide varistor (MOV) type surge protection. Photocell to be designed for 20-year service to match life expectancy of long-life LED fixtures and exceeds 15,000 operations at full load. Provide photocell with zero-cross technology to withstand severe in-rush current and extend relay life.

#### 2.3.2 Timeswitch

Timeswitch shall be electromechanical type with a 24 hour 7 day astronomic dial. Switch shall be powered by an enclosed synchronous motor with a maximum 3 watt operating rating. Timeswitch contacts shall be rated for 40 amps at 120-277 VAC resistive load in a SPDT normally open (NO) configuration. Switch shall have an automatic spring mechanism to maintain accurate time for up to 16 hours during a power failure. Provide switch with manual bypass or remote override control.

Timeswitch shall be housed in a surface-mounted, lockable NEMA 3R enclosure constructed of painted steel or plastic polymer conforming to NEMA ICS 6.

#### 2.3.3 Lighting Contactor

NEMA ICS 2. Provide a mechanically-held lighting contactor housed in a NEMA 3R enclosure conforming to NEMA ICS 6. Contactor shall have 6 poles, configured as normally open (NO). Contacts shall be rated 600 volts, 30 amperes for a resistive load. Coil operating voltage shall be 480 volts. Contactor shall have silver cadmium oxide double-break contacts and shall require no arcing contacts. Provide contactor with hand-off-automatic selector switch. Provide contactor as specified above along with disconnect switch in integral NEMA 3R enclosure with flange-mounted handle to satisfy requirement for a "combination lighting contactor" when specified.

#### 2.4 POLES

Provide poles designed for wind loading of 100 miles per hour determined in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be anchor-base type designed for use with underground supply conductors. Poles shall have oval-shaped handhole having a minimum clear opening of 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws. Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

##### 2.4.1 Aluminum Poles

Provide aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Tops of shafts shall be fitted with a round or tapered cover. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel. Aluminum poles and brackets for lighting shall have a uniform satin finish to match fixtures and shall not be painted. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.

#### 2.5 BRACKETS AND SUPPORTS

ANSI C136.3, ANSI C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 1 1/4 inch galvanized steel pipe secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height

indicated. Mount brackets not less than 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

## 2.6 POLE FOUNDATIONS

Anchor bolts shall be steel rod having a minimum yield strength of 50,000 psi; the top 12 inches of the rod shall be galvanized in accordance with ASTM A153/A153M. Concrete shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

## 2.7 EQUIPMENT IDENTIFICATION

### 2.7.1 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.

### 2.7.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. Luminaires shall be clearly marked for operation of specific light sources and ballasts according to proper light source type. The following light source characteristics shall be noted in the format "Use Only \_\_\_\_":

- a. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

Markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place.

## 2.8 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

#### 3.1.1 Aluminum Poles

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. Install according to pole manufacturer's instructions.

Alterations to poles after fabrication will void manufacturer's warranty and shall not be allowed.

### 3.1.2 Pole Setting

Depth shall be as indicated. Poles in straight runs shall be in a straight line. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 6 inch maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

### 3.1.3 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations. Set adjustable window slide for 5 footcandles photocell turn-on.

### 3.1.4 GROUNDING

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

### 3.1.5 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.

## 3.2 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test after 100 hours of burn-in time to show that the equipment operates in accordance with the requirements of this section.

-- 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

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 (2016) Indoor Optical Fiber Cables

ICEA S-90-661 (2012) Category 3, 5, & 5e Individually  
Unshielded Twisted Pair Indoor Cables for  
Use in General Purpose and LAN  
Communications Wiring Systems Technical  
Requirements

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568 (2006) Standard for Installing Building  
Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66 (2013) Performance Standard for Category 6  
and Category 7 100 Ohm Shielded and  
Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA  
20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
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-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
ANSI/TIA-568.0-D	(2015) Generic Telecommunications Cabling for Customer Premises
ANSI/TIA-568.1-D	(2018) Commercial Building Telecommunications Cabling
ANSI/TIA-568.2-D	(2018) Balanced Twisted-Pair Telecommunications Cabling and Components
ANSI/TIA-568.3-D	(2016) Optical Fiber Cabling Components
ANSI/TIA-569	(2019e) Commercial Building Standard for Telecommunications Pathways and Spaces
ANSI/TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
ANSI/TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-1152	(2009) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA-604-3	(2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3
TIA-604-10	(2008) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)
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UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
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UL 444	(2008; Reprint Apr 2015) Communications Cables
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 514C	(2014; Reprint Nov 2018) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2008; Reprint Jan 2018) UL Standard for Safety Office Furnishings
UL 1666	(2007; Reprint Jun 2012) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Sep 2016) UL Standard for Safety Communication Circuit Accessories

## 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 ANSI/TIA-568.1-D, ANSI/TIA-568.2-D, ANSI/TIA-568.3-D, ANSI/TIA-569, ANSI/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. 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" 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

### SD-02 Shop Drawings

Telecommunications drawings; G

Telecommunications Space Drawings; G

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

Patch panels; G

Telecommunications outlet/connector assemblies; G

Equipment support frame; G

Connector blocks; G

Telecom Cabinets; G

Spare Parts; G

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

### SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test plan; G

SD-09 Manufacturer's Field Reports

Factory reel tests; G

SD-10 Operation and Maintenance Data

Telecommunications cabling and pathway system Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

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 ANSI/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 ANSI/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, CDs, and FDs 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 ANSI/TIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, 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.

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years' experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory

approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. 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 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 [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#) and [ANSI/TIA-568.3-D](#).

#### 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 ANSI/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 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 ANSI/TIA-606. The cable records shall include only the required data fields in accordance with ANSI/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 ANSI/TIA-606. Documentation shall include the required data fields as a minimum in accordance with ANSI/TIA-606.

#### 1.10.3 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.

### 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.

#### 2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with ANSI/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 ANSI/TIA-568.0-D, ANSI/TIA-568.1-D, ANSI/TIA-568.2-D, ANSI/TIA-568.3-D and NFPA 70. Provide a labeling system for cabling as required by ANSI/TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date 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, 50-pair, Category 3, UTP, in accordance with ICEA S-90-661, ANSI/TIA-568.1-D, ANSI/TIA-568.2-D and UL 444, formed into 25 pair binder groups covered with a thermoplastic jacket and overall metallic shield. 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, ANSI/TIA-568.3-D, 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, (but not less than 12 strands between the main telecommunication room and each of the other telecommunication rooms), of single-mode(OS1), tight buffered fiber optic cable.

Provide tight buffered fiber optic single-mode, cable as indicated.

Provide plenum (OFNP), 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-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-598.

### 2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with ANSI/TIA-568.1-D.

#### 2.3.2.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with [ANSI/TIA-568.2-D](#), [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 thermoplastic jacket. 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) 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 [ANSI/TIA-568.3-D](#). 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), 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 of cordage jacket, fiber, unit, and group in accordance with [TIA-598](#).

### 2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment room to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with [ANSI/TIA-606](#).

#### 2.4.1 Backboards

Provide void-free, interior grade A-C plywood 3/4 inch thick, 4 by 8 feet. Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Paint applied over fire retardant backboard shall be [UL 723](#) fire retardant paint. Provide label including paint manufacturer, date painted, UL listing and name of Installer. When painted, paint label and fire stamp shall be clearly visible. Backboards shall be provided on all four walls in the telecommunication spaces.

#### 2.4.2 Equipment Support Frame

Provide in accordance with [EIA/ECA 310-E](#) and [UL 50](#).

- a. [Telecom cabinets](#), freestanding modular type, 16 gauge steel or 11 gauge aluminum construction, minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. Cabinet shall be vented in the roof and front and rear door. Cabinet shall have cable access in the roof and base and be compatible with 19 inches panel mounting. Provide cabinet with grounding bar. Cabinets may require different



keys. 377 MSG/SC shall determine which cabinets are keyed alike once telecom design is complete.

#### 2.4.4.3 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. Use of 66 blocks for backbone copper cables is preferred.

#### 2.4.4.4 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment cabinets and telecommunications backboards. Cable guides of ring or bracket type devices mounted on cabinet and backboard for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, and or nuts and lockwashers.

#### 2.4.4.5 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. Coordinate lengths with the comm squadron. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with ANSI/TIA-568.3-D. Patch cords shall meet minimum performance requirements specified in ANSI/TIA-568.1-D, ANSI/TIA-568.2-D and ANSI/TIA-568.3-D for cables, cable length and hardware specified.

##### 2.4.5.1 Modular to 110 Block Patch Panel

Provide in accordance with ANSI/TIA-568.1-D and ANSI/TIA-568.2-D. Panels shall be third party verified and shall comply with ANSI/TIA Category 6 requirements. Panel shall be constructed of 0.09 inch minimum aluminum and shall be cabinet mounted and compatible with an EIA/ECA 310-E 19-inch equipment cabinet. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568B. 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 rack-mounted and compatible with a EIA/ECA 310-E 19 inches equipment rack. Each panel shall provide 12 single-mode adapters as duplex LC in accordance with TIA-604-10 with zirconia ceramic 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-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 multimode pigtails 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](#), [ANSI/TIA-568.1-D](#), and [ANSI/TIA-568.2-D](#). 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 and shall comply with [ANSI/TIA-568.2-D](#) Category 6 requirements. 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 both T568A and T568B wiring. Each outlet/connector shall be wired T568B. UTP outlet/connectors shall comply with [ANSI/TIA-568.2-D](#) for 200 mating cycles. UTP outlet/connectors installed in outdoor or marine environments shall be jell-filled type containing an anti-corrosive, memory retaining compound.

#### 2.5.2 Optical Fiber Adapters (Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with [TIA-604-10](#) with zirconia ceramic alignment sleeves (SMARTNET) and duplex SC in accordance with [TIA-604-3](#) with zirconia ceramic alignment sleeves (SIPR) 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-604-10](#) with zirconia ceramic alignment sleeves (SMARTNET) and duplex SC (SIPRNET) in accordance with [TIA-604-3](#) with zirconia ceramic alignment sleeves, epoxyless crimp style compatible with 50/125 multimode (horizontal) and 8/125 single-mode fiber (backbone). The connectors shall provide a maximum attenuation of 0.3 dB at 850 for multimode and 1310 nm for single mode with less than a 0.2 dB change after 500 mating cycles.

#### 2.5.4 Cover Plates

Telecommunications cover plates shall comply with [UL 514C](#), and [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#), [ANSI/TIA-568.3-D](#); angled and flush design constructed of high impact thermoplastic material to match color of receptacle/switch cover plates specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM and Type 302 stainless material for wall phones. Provide labeling in accordance with the paragraph LABELING in this section.

#### 2.5.5 MUTOA(s)

Provide MUTOA(s) in accordance with ANSI/TIA-568.1-D. A minimum of 12 connection ports are required.

#### 2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, ANSI/TIA-607, and NFPA 70. Components shall be identified as required by ANSI/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 ANSI/TIA-568.1-D, ANSI/TIA-568.2-D, ANSI/TIA-568.3-D, TIA-526-7 for single mode optical fiber, and TIA-526-14 for multimode 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 NECA/BICSI 568, ANSI/TIA-568.1-D, ANSI/TIA-568.2-D, ANSI/TIA-568.3-D, ANSI/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.

### 3.1.1.1 Cabling

Install UTP and optical fiber telecommunications cabling system as detailed in [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#), and [ANSI/TIA-568.3-D](#). 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.

#### 3.1.1.1.1 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. Copper Backbone Cable (at telecom rooms) shall meet the requirements of Kirtland Air Force Base Communications Specifications 11.4.2.
- 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 the form of a figure eight (not a service loop) on each end of the cable, [10 feet](#) in the telecommunications room, and [12 inches](#) in the work area outlet.

#### 3.1.2 Pathway Installations

Provide in accordance with [ANSI/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 Section [26 20 00](#) INTERIOR DISTRIBUTION

SYSTEM. Only CMP and OFNP type cable shall be installed in a plenum.

### 3.1.5 Work Area Outlets

#### 3.1.5.1 Terminations

Terminate UTP cable in accordance with [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#) and wiring configuration as specified. Terminate fiber optic cables in accordance with [ANSI/TIA-568.3-D](#).

#### 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

Unshielded twisted pair and fiber optic cables shall have a minimum of [12 inches](#) of slack cable loosely coiled into the telecommunications outlet boxes. 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 [ANSI/TIA-569](#).

#### 3.1.6.2 Patch Panels

Patch panels shall be mounted in equipment cabinets 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 Velcro cable ties as recommended by the manufacturer to prevent movement of the cable.
- b. Fiber Optic Patch Panel. Fiber optic cable loop shall be provided as recommended by the manufacturer. 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 [ANSI/TIA-569](#):

- a. Bracket, wall mounted. Mount bracket to plywood backboard in accordance with manufacturer's recommendations. Mount rack so height of highest panel does not exceed 78 inches above floor (commercial systems only).
- b. Cabinets, freestanding modular type.

### 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 ANSI/TIA-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

## 3.2 LABELING

### 3.2.1 Labels

See Kirtland Air Force Base Communications Specification for requirements on labeling. For any questions or matters not addressed there, refer to ANSI/TIA-606 for labeling requirements.

### 3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with ANSI/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 ANSI/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 Painting Backboards

If backboards are required to be painted, then the manufactured fire-retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

## 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 [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#), [ANSI/TIA-568.3-D](#). 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 [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#), [ANSI/TIA-568.3-D](#). 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 multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with [ANSI/TIA-568.3-D](#) and [TIA-526-14](#) using Method A, Optical Power Meter and Light Source for multimode optical fiber. For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with [ANSI/TIA-568.3-D](#) and [TIA-526-7](#) using Method A, Optical Power Meter and Light Source for single-mode optical fiber.

##### 3.5.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

- a. Perform Category 6 link tests in accordance with [ANSI/TIA-568.1-D](#) and [ANSI/TIA-568.2-D](#). 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 [ANSI/TIA-568.3-D](#).

##### 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.

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## 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

###### SD-05 Design Data

Test Plan; G

###### SD-06 Test Reports

Draft Test Report

Final Test Report; G

###### 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 5 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 2 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 2 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

Clearly establish the scope for ESS testing prior to beginning testing. Submit a Test Plan that addresses 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.

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 meet specific project requirements and develop additional ones 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. Conduct testing in two phases - functional testing followed by burn-in testing.

#### 3.2.1 Phased Testing

##### 3.2.1.1 Functional Testing Phase

During the functional testing phase, verify system performance in accordance with 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.

##### 3.2.1.2 Burn-In Testing Phase

Begin burn-in testing after successful completion of all functional testing. During the burn-in testing phase, place the ESS in normal operating mode and evaluate system performance for a continuous 72-hour period. During this time, the ESS must be fully functional and programmed such that all features can be exercised and evaluated through normal use. Record all system anomalies in approved Test Logs. Include a description of each anomaly along with any actions taken in response. Immediately correct minor deficiencies observed during the course of testing and continue with burn-in testing. Determine the root cause of any failures

and make necessary repairs or modifications to restore full functionality. After a failure is corrected repeat functional tests for components and features associated with the failure and repeat the entire burn-in testing phase.

### 3.2.2 Draft Test Report

Prepare and submit a Draft Test Report 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.

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.

### 3.3.1 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.

### 3.3.2 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.

### 3.3.3 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 along with a complete set of ESS red line drawings to be used during the inspection. Document deficiencies identified during the inspection.

### 3.3.4 Functional Testing

Comply with requests from the Government Representative to repeat functional tests performed previously during pre-acceptance testing. 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. Add all test results to approved Test Logs.

### 3.3.5 System Activity Reports

Retrieve archived data from the system and provide 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.

### 3.3.6 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.

## 3.4 FINAL TEST REPORT

Submit a [Final Test Report](#) following the successful completion of acceptance testing to include 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.

-- End of Section --

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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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ASC/X9 X9.52 (1998) Triple Data Encryption Algorithm  
Modes of Operation

ASTM INTERNATIONAL (ASTM)

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

ASTM B32 (2008; R 2014) Standard Specification for  
Solder Metal

ASTM D709 (2017) Standard Specification for  
Laminated Thermosetting Materials

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.23 (2010) Electromagnetic Locks

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3 (2018) Ethernet

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017)  
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 (2018) Enclosures for Electrical Equipment  
(1000 Volts Maximum)

NEMA ICS 1 (2000; R 2015) Standard for Industrial

Control and Systems: General Requirements

NEMA ICS 2 (2000; R 2005; Errata 2008) 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 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA  
20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2 (2001) Security Requirements for  
Cryptographic Modules

NIST FIPS 197 (2001) Advance Encryption Standard

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 (2005G; Add 1 2007; Add 2 2009; Add 3  
2014; Add 4 2014; R 2014; R 2016)  
Structural Standards for Steel Antenna  
Towers and Antenna Supporting Structures

TIA-568.2-D Balanced Twisted-Pair Telecommunications  
Cabling and Components Standards

TIA-606 (2017c) Administration Standard for the  
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 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 May 2012) Standard for Intrusion Detection Units
UL 681	(2014) Installation and Classification of Burglar and Holdup Alarm Systems
UL 796	(2016) 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) UL Standard for Safety Proprietary Burglar Alarm Units and Systems
UL 1610	(2016) UL Standard for Safety Central-Station Burglar-Alarm Units

1.2 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

ESS Components; G

Overall System Schematic; G

SD-03 Product Data

Premise Control Unit; G

Detection Sensors; G

Access Control Unit; G

Access Control Devices; G

Cameras; G

Camera Lenses; G

Camera Housing and Mounts; G

Video Recording; G

Printers; G

Communications Interface Devices; G

Radio Frequency Link; G

Video and ESS Transmission; G

Batteries; G

Component Enclosure; G

Equipment Rack; G

#### SD-05 Design Data

Backup Battery Capacity Calculations; G

Access Control Throughput Rates; G

CCTV Storage Calculations

#### SD-07 Certificates

Contractor Qualifications; G

Instructor Qualifications; G

Data Encryption; G

#### SD-10 Operation and Maintenance Data

Training Plan; G

Training Content; G

ESS Components and ESS Software: Data Package 4; G

ESS Software and ESS Components: Data Package 4; G

Submit data package in accordance with Section 01 78 23  
OPERATION AND MAINTENANCE DATA

#### SD-11 Closeout Submittals

As-Built Drawings; G

### 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) CCTV 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. 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 nonfungal 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.

#### 1.4.2 Exterior Conditions

Components in enclosures must meet performance requirements when exposed to the following ambient conditions:

##### 1.4.2.1 Temperature

Minus 40 to 140 degrees F.

##### 1.4.2.2 Pressure

Sea level to 15,000 feet above sea level.

##### 1.4.2.3 Solar Radiation

Six hours of solar radiation per day at dry bulb temperature of 120 degrees F including 4 hours of solar radiation at 104 watts per square foot.

1.4.2.4 Sand and Dust

Wind driven for up to 6 miles per hour (mph).

1.4.2.5 Rain

2 inches per hour and 5 inches per hour cyclic with wind plus one period of 12 inches per hour.

1.4.2.6 Humidity

5 to 95 percent.

1.4.2.7 Fungus

Warm, humid atmosphere conducive to the growth of heterotropic plants.

1.4.2.8 Snow

Snow loading of 48 (psf) per hour; blowing snow of 4.6 psf per hour.

1.4.2.9 Ice Accretion

Up to 1/2 inches of radial ice.

1.4.2.10 Wind

Continual velocity up to 50 mph with gusts to 66 mph, except that fence sensors must detect intrusions up to 35 mph.

1.4.2.11 Acoustical Noise

Components must be suitable for use in high noise areas above 110 dB without adversely affecting their performance. Examples areas include flight lines, runup pads, and generator sites.

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 CCTV 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 and integrated electronic security system (ESS) that meet requirements of Kirtland Air Force Base. ESS must be compatible with the Installation's central monitoring system and monitored within the secure/protected area and at the Installation central monitoring station. ESS consisting of the following subsystems and features:

- a. Intrusion Detection System (IDS)
- b. Access Control System (ACS)
- c. Closed-circuit Television System (CCTV)
- d. Security Command Center (SCC)
- e. Communications System
- f. Security Lighting Systems
- g. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

#### 2.2 PERFORMANCE REQUIREMENTS

Integrate the installed and operating subsystems into the overall ESS

system to detect intrusion, control access, provide CCTV 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.

#### 2.2.2.1 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.

#### 2.2.2.2 Hazardous Locations

When located in areas where fire or explosion hazards exist, provide system components rated and installed according to Chapter 5 of NFPA 70.

#### 2.2.2.3 Network Certification

Certify all Platform Information Technology (PIT) in accordance with DODI 8500.01 and the individual service implementation policy.

#### 2.2.2.4 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.

#### 2.2.2.5 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.

#### 2.2.2.6 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.

#### 2.2.2.7 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.

#### 2.2.8 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 Secured Area and the Security Command Center to clearly identify the component experiencing power loss.

#### 2.2.9 Controls and Designations

Provide controls and designations as specified in NEMA ICS 1.

#### 2.2.10 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.

#### 2.2.11 Electromagnetic Interference (EMI)

Configure and provide ESS components employing electromagnetic radiation constructed to provide minimal vulnerability to electronic countermeasures.

#### 2.2.12 Electromagnetic Radiation (EMR)

Provide only ESS communication components which are Federal Communications Commission (FCC) licensed and approved. Provide system components which are electromagnetically compatible.

#### 2.2.13 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 integrated 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 that seamlessly integrates with the ESS under a single operating environment. 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 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

### 2.3.2 Detection Sensitivity

The sensitivity of the IDS must allow for the following:

- a. Locating intrusions at individually protected assets or at an individual portal
- b. Locating intrusions within the coverage on a single volumetric sensor
- c. Locating failures or tampering at individual sensors

### 2.3.3 Detection Alarm and Reporting Capacity

Collect, communicate, and display up to 32 sensor zone alarms and to enable control of two card reader for arming and disarming inside of the protected area with a delayed alarm.

Identify individual sensors in alarm if the sensor zone is a multiple alarm source combination. Annunciate a single alarm within 2 seconds 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 8 keypads with alphanumeric display. Each keypad must be capable of arming and disarming 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.
- c. Four 4 shift schedules per area.
- d. A total of at least 100 programmable output relay schedules.
- e. 64 individual reporting areas.
- f. Data line supervision.
- g. Two-man access code or credentials.
- h. 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.
- i. 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.
- j. 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.
- k. Support a Network Interface Card (NIC) plug-in module with built in network router capable of 128 Bit AES Rijndael Encryption process certified by NIST (National Institute of Standards and Technology).

#### 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. Phone trouble line 1
- g. Phone trouble line 2
- h. Transmit trouble
- i. Network trouble

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 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 Balanced Magnetic Switch (BMS)

Mount the BMS inside the secure location and on the opening side of the door. BMS sensors do not have the capability to incorporate an end-of-line (EOL) resistor.

2.3.7.1.1.1 Level 1 Switch

UL 634. Level 1 High Security

2.3.7.1.1.2 Level 2 Switch

UL 634. Level 2 High Security

2.3.7.1.2 Glass Break Detection

UL 639.

2.3.7.1.2.1 Window-Mounted Glass Break Shock Sensor

Not used.

2.3.7.1.2.2 Ceiling or Wall-Mounted Dual Technology Glass Break Sensor

Not used.

2.3.7.1.2.3 Ceiling or Wall-Mounted Recessed Glass Break Sensor

Not used.

2.3.7.1.3 Vibration Vault Sensor

Provide a sensor that senses short duration, large amplitude signals like those produced in attacks from explosions, hammering or chiseling and also detect long duration, small amplitude signals like those produced in attacks from torches, thermic lances, drills, grinders, or cutting discs.

Provide sensor equipped with a manual and an automatic test alarm output with test indicator not visible or audible during normal operations. The test indicator is to annunciate when the sensor detects an intruder when active. The alarm indication may be located within the sensor or as a separate device.

2.3.7.1.4 Fiber Optic Mesh Sensors

Not used.

2.3.7.1.5 Utility Inlet Opening Protection

Not used.

2.3.7.1.6 Passive Infrared Sensors

UL 639.

2.3.7.1.7 Microwave Sensors

UL 639.

2.3.7.1.8 Dual Technology Sensors

UL 639. Provide sensor combining passive infrared (PIR) and microwave sensors configured and manufactured specifically to be mounted in a single tamper alarmed enclosure. The sensor must provide selectable "AND" logic or "OR" logic for alarm indication configured in the "OR" logic state.

Provide sensors that have a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

The sensor is to have an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator will light when the sensor detects an intruder. Provide a sensor equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

#### 2.3.7.1.9 Photoelectric Sensors

UL 639. The sensor is to detect opaque bodies and not allow an intruder to disable detection by shining another light source into the receiver.

Provide sensor with a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

#### 2.3.7.2 Exterior Sensors

##### 2.3.7.2.1 Fence Mounted Sensors

Not used.

##### 2.3.7.2.1.1 Fiber Optic Sensor

Not used.

##### 2.3.7.2.1.2 Strain-Sensitive

Not used.

##### 2.3.7.2.1.3 Gas Units

Provide a gate unit for each fence portal.

Provide separately zoned BMS gate sensors. BMS sensors perform as specified in paragraph HIGH SECURITY BALANCED MAGNETIC SWITCH (BMS).

##### 2.3.7.2.2 Electrostatic Field Sensors

Not used.

##### 2.3.7.2.3 Taut-Wire Sensors

Not used.

##### 2.3.7.2.4 Dual Technology Sensors

Not used.

##### 2.3.7.2.5 Bistatic Microwave Sensor

Not used.

##### 2.3.7.2.6 Monostatic Microwave Sensor

Not used.

2.3.7.2.7 Passive Infrared Sensor (Exterior)

Not used.

2.3.7.2.8 Buried Ported Cable

Not used.

2.3.7.2.9 Active Infrared Sensor (Exterior)

Not used.

2.3.7.2.10 Video Motion Sensor (Exterior)

Not used.

2.3.7.2.11 Radar

Not used.

2.3.7.3 Duress Alarms (Hold Up Switch)

Not used.

2.3.7.3.1 Hardwire Duress Alarms

Not used.

2.3.7.3.2 Wireless Duress Alarms

Not used.

2.3.7.4 Tamper Switches

- a. Corrosion-resistant tamper switches are required for the following IDS and CCTV 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 have a maintenance position. Provide two positions tamper switches.

#### 2.3.7.4.1 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 individually by zone at the central reporting processor.

#### 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 system monitoring and control for the ESS. Provide ACS that meets the communications requirements of [UL 1076](#) and [UL 294](#) and has the capability of controlling up to 16 card readers and keypads per card reader controller, 256 alarm inputs, or 256 relay outputs or any components combination.
- b. System is to grant or deny access or exit based upon:
  - (1) Keypad identification data
  - (2) CAC card identification data
  - (3) 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. Access decisions for high security areas are to be based upon two identification technology combinations: card and keypad.
- 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 Badging Requirements

Include fully integrated badging capabilities, including image capture, image editing, badge design, and badge printing. Allow for each cardholder to be assigned to both a badge design formatted for badge printing and a dossier design formatted for standard paper printing. The system must permit the storage of four different images:

- a. Main photograph
- b. Alternate photograph
- c. Signature
- d. Fingerprint

Provide for interfacing with external badge programs, in which stored photo images are displayed in a cardholder information window, but other badge features are supported by the external program. Include one or more networked PC workstations with the photo imaging components at which all of the required image capture equipment has been installed.

#### 2.4.2 ACS Programming

Provide software capable of, but not limited to, the following programming:

##### 2.4.2.1 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.

#### 2.4.2.2 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.

#### 2.4.2.3 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.

#### 2.4.2.4 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.

#### 2.4.2.5 Maximum User Capability

Up to 64,000 individual users may be given access cards or codes and have their access controlled and recorded.

#### 2.4.2.6 Access Groups

Each system user must be assignable to a maximum of 100 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.

#### 2.4.2.7 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.

#### 2.4.2.8 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.

#### 2.4.2.9 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.

#### 2.4.2.10 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.

#### 2.4.2.11 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.

#### 2.4.2.12 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.

#### 2.4.2.13 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.

#### 2.4.2.14 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.

#### 2.4.2.15 PIN Required

Provide support for the required use of a keypad code, in addition to a valid credential during user-selected schedules.

#### 2.4.2.16 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.

#### 2.4.2.17 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.

#### 2.4.2.18 Guard Tour

Provide support for user-defined guard tours configurable in a set pattern of tour points, or following a mode in which all tour points can be visited in any order within an allotted time. Allow for a tour to be started by ACS command, by use of a selected card at a selected reader, or by use of a selected keypad code at a selected keypad. Detect guard late-to-point, point missed, and point out-of-sequence events. Generate a report at tour completion.

#### 2.4.2.19 Reader Disable

Provide support for disabling readers in reaction to a user-selected number of invalid access attempts.

#### 2.4.2.20 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.

#### 2.4.2.21 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.

#### 2.4.2.22 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.

#### 2.4.2.23 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.

#### 2.4.2.24 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.

#### 2.4.2.25 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.

#### 2.4.2.26 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.

#### 2.4.2.27 User-Selected LED Behavior

Allow the user to select different behaviors for the LEDs of each access controlled reader.

#### 2.4.2.28 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.

#### 2.4.2.29 Badge Print Tracking

Support setting a print limit for any badge. The software will track the number of times any badge has been printed, as well as display the date and time of the most recent printing.

#### 2.4.3 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.

#### 2.4.4 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 32 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 Ethernet 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.

#### 2.4.5 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 or RS-232 hardwired, 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 16 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 16 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
- (4) Elevator Reader
- (5) Elevator Output Module

Any device combination can be supported on each ACU, up to a total of 16 devices per ACU.

- d. Capability of supporting multiple card reader technologies simultaneously, including:

- (1) Keypad
- (2) Card and Keypad
- (3) CAC compatible

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.

#### 2.4.6 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.

##### 2.4.6.1 Card Readers

Provide semiflush card readers as indicated for each individual location. Provide 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 as a stand-alone device.

##### 2.4.6.1.1 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.

##### 2.4.6.1.2 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.

##### 2.4.6.1.3 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.

##### 2.4.6.1.4 Card Reader Response Time

The card reader is to respond to passage requests by generating a signal to the local processor.

##### 2.4.6.1.5 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.

##### 2.4.6.1.6 Card Reader Mounting Method

Provide card readers suitable for semi-flush mounting as required.



#### 2.4.6.2 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.

##### 2.4.6.2.1 Keypad Display

Keypads are to include an LED or other type of visual indicator display and provide visual 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.

##### 2.4.6.2.2 Keypad Response Time

The keypad is to respond to passage requests by generating a signal to the local processor.

##### 2.4.6.2.3 Keypad Power

Power the keypad from the source as shown on the drawings. The keypad must not dissipate more than 5 Watts.

##### 2.4.6.2.4 Keypad Mounting Method

Provide keypads suitable for semi-flush mounting as required.

##### 2.4.6.2.5 Keypad Duress Codes

Provide a means for users to indicate a duress situation by entering a special code into the keypad.

#### 2.4.6.3 Card Readers with Integral Keypad

Equip contact and contactless card readers with integral keypads as specified in paragraph "Keypads".

#### 2.4.6.4 Access Control Cards

Not used.

##### 2.4.6.4.1 Credential Card Modification

Not used.

##### 2.4.6.4.2 Card Size and Dimensional Stability

Not used.

#### 2.4.6.4.3 Card Materials and Physical Characteristics

Not used.

#### 2.4.6.4.4 Card Construction

Not used.

#### 2.4.6.4.5 Card Durability and Maintainability

Not used.

#### 2.4.6.4.6 Warranty

Include a minimum 3-year warranty.

#### 2.4.6.5 Personal Identity Verification Equipment

Not used.

#### 2.4.6.6 Portal Control Devices

Portal control devices must meet the requirements in Section 08 71 00 DOOR HARDWARE.

##### 2.4.6.6.1 Push-Button Switches

- a. Provide momentary contact, back lit push buttons and stainless steel switch enclosures for each push button. Provide switch enclosures suitable for flush mounting as required and push buttons suitable for flush mount in the switch enclosures. The push button switches are to meet the requirements of NEMA 250 for the area in which they are to be installed.
- b. Where multiple pushbuttons are housed within a single switch enclosure stack vertically with each push button switch labeled with 1/4 inch high text and symbols. The push button switches are to be connected to the local processor associated with the portal to which they are applied and operate the appropriate electric strike, electric bolt or other facility release device.
- c. The continuous current of the IDS circuit is to be no more than 50% of the continuous current rating of the device supplied. Provide push button switches with double-break silver contacts that will make 720 VA at 60 amperes and break 720 VA at 10 amperes.

##### 2.4.6.6.2 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. Provide panic bar compatible with mortise-mount door hardware and operate by retracting the bolt.

##### 2.4.6.6.2.1 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.

#### 2.4.6.6.2.2 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.

#### 2.4.6.6.2.3 Delay 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.

Delay operation 15 seconds after initiation for portal control devices.

#### 2.4.6.6.3 Electric Door Strikes and Bolts

Configure electric door strikes and bolts to remain secure in case of power failure using DC power to energize the solenoids. 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. Electric strikes must have a minimum forcing strength of 2300 pounds.

##### 2.4.6.6.3.1 Solenoid

The actuating solenoid for the strikes and bolts furnished must not dissipate more than 12 Watts and operate on 24 VDC. 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.

##### 2.4.6.6.3.2 Signal Switches

Strikes and bolts are to include signal switches indicating to the system when the strike mechanism is unlocked. The signal switches are to report a forced entry to the system.

##### 2.4.6.6.3.3 Tamper Resistance

The electric strike and bolt mechanism is to be encased in hardened guard barriers to deter forced entry.

##### 2.4.6.6.3.4 Size and Weight

Electric strikes and bolts are to be compatible with standard door frame preparations.

#### 2.4.6.6.3.5 Mounting Method

Provide electric strikes and bolts suitable for use with single and double door installations, with mortise-type hardware as indicated, and compatible with right or left hand mounting.

#### 2.4.6.6.3.6 Astragals

See Section 08 71 00 DOOR HARDWARE for Astragal lock guards.

#### 2.4.6.6.4 Electrified Mortise Lock

Configure electrified mortise locks to remain secure in case of power failure using DC power to energize the solenoids. 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.

##### 2.4.6.6.4.1 Solenoid

The actuating solenoid for the mortise locks furnished must not dissipate more than 12 Watts and operate on 24 VDC. 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.

##### 2.4.6.6.4.2 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.

##### 2.4.6.6.4.3 Hinge

Provide an electric transfer hinge with each mortise lock in order to get power and monitoring signals from the lockset to the door frame.

##### 2.4.6.6.4.4 Size and Weight

Electrified mortise locks are to be compatible with standard door preparations.

##### 2.4.6.6.4.5 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.

#### 2.4.6.6.5 Electromagnetic Lock

Electromagnetic locks are to contain no moving parts and depend solely upon electromagnetism to secure a portal by generating at least 1200 pounds of holding force. Interface the lock with the local processors without external, internal or functional local processor alteration. Incorporate an end-of-line resistor to facilitate line supervision by the system. Install MOVs to protect the controller from reverse current surges if not incorporated into the electromagnetic lock or local controller. Provide

in accordance of ANSI/BHMA A156.23.

#### 2.4.6.6.5.1 Armature

The electromagnetic lock is to contain internal circuitry to eliminate residual magnetism and inductive kickback. The actuating armature must operate on 24 VDC and not dissipate more than 12 Watts. The holding current must be not greater than 500 milli-amperes. The actuating armature must take not more than 300 milli-seconds to change the status of the lock from fully secure to fully open or fully open to fully secure.

#### 2.4.6.6.5.2 Tamper Resistance

The electromagnetic lock mechanism is to be encased in hardened guard barriers to deter forced entry.

#### 2.4.6.6.5.3 Mounting Method

Provide electromagnetic lock suitable for use with single and double door installations with mortise-type hardware as indicated, and compatible with right or left hand mounting.

#### 2.4.6.6.6 Entry Booth

Not used.

#### 2.4.6.6.7 Vehicle Gate Operator

Provide vehicle gate operators suitable for connection to, monitoring, and control by the system's local processors and include all additional equipment and wiring to be an operable system. Provide a hand crank for the manual vehicle gate operator and a solenoid actuated brake operation to prevent gate coasting.

Provide an auto reverse time delay of at least 1 second and not more than 3 seconds to minimize shock loads on vehicle gate operator drive components. Include a contactor type motor starter that is appropriate for the gate operator motor.

##### 2.4.6.6.7.1 Input Power

Provide vehicle gate operator that operates from the voltage source as shown on the drawings. Include manual reset type thermal and electrical overload devices.

##### 2.4.6.6.7.2 Audible Warning

Provide an audible warning system to signal personnel in the vicinity of the vehicle gate operator that an opening or closing is about to commence. The audible warning must sound at least 2 seconds and no more than 5 seconds before movement begins.

##### 2.4.6.6.7.3 Maximum Run Timer

The vehicle gate operator must incorporate an internal maximum run timer which limits the motor run time. The maximum run time is to be operator adjustable for at least the maximum amount of time gate opening or closing takes during normal operation.

#### 2.4.6.6.7.4 Adjustable Load Monitor for Obstruction Sensing

Provide operator adjustable load monitor that senses obstructions in the path of the gate and automatically reverses the vehicle gate operator drive motor. Do not allow the gate to open once the gate has reached the limit switch.

#### 2.4.6.6.7.5 Operator Override Controls

Provide the vehicle gate operator with an interface to a three pushbutton control station located within an entry controlled area. The three pushbutton switches are to be labeled and function as Open, Close, and Stop controls, and meet the requirements of paragraph Pushbutton Switches.

#### 2.4.6.6.7.6 Limit Switches

Provide adjustable limit switches to define the range of gate travel and provide a means to securely lock the switches in place after adjustment.

#### 2.4.6.6.7.7 Type of Gate

Provide the vehicle gate operators to be compatible with cantilever, roller, v-track, overhead, slide, and swing gates.

#### 2.4.6.6.7.8 Safety

Provide safety compatible with paragraph "Type of Gate" for entrapment protection.

#### 2.4.7 Elevator Control

Not used.

### 2.5 CLOSED-CIRCUIT TELEVISION (CCTV) SYSTEM

Select system components that conform to the Open Network Video Interface Forum (ONVIF) specification. Provide compatible UL listed CCTV 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 CCTV 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 over a voltage range of 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 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. Receiver-driver
- e. Pan-tilt control system
- f. Pre-position cards
- g. Heavy duty bearings
- h. Hardened steel gears
- i. Permanent lubrication
- j. Motors that are thermally or impedance protected against overload damage.
- k. 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.

#### 2.5.1.3.6 Exterior Dome Housing

Provide dome housing capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings and constructed to be dust and water tight, and fully operational in 100 percent condensing humidity. Purge the housing of atmospheric air and pressurize with dry nitrogen. Provide a fill valve and overpressure valve with a pressure indicator visible from the exterior. The housing is to be equipped with supplementary camera mounting blocks or supports as needed to position the specified camera and lens to maintain the proper optical centerline.

Provide all electrical and signal connections required for camera and lens operation. The housing is to provide the environment needed for camera operation. The lower dome is to be black opaque acrylic with 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. Receiver-driver
- e. Pan-tilt control system
- f. Pre-position cards

- g. Heavy duty bearings
- h. Hardened steel gears
- i. Permanent lubrication
- j. Motors that are thermally or impedance protected against overload damage.
- k. 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.

#### 2.5.1.3.7 Exterior Wall Mount

Provide exterior camera wall mount that is 24 inches long and has an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum, stainless steel, or steel with a corrosion-resistant finish. Provide adjustable head for at least plus and minus 90 degrees of pan, and at least plus and minus 45 degrees of tilt. If to be used in conjunction with a pan-tilt, provide bracket without the adjustable mounting head, and a bolt hole pattern to match the pan-tilt base.

#### 2.5.1.3.8 Pan-Tilt Mount

- a. Provide pan-tilt mount capable of supporting the camera, lens, and housing specified that is weatherproof and sized to accommodate the camera, lens and housing weight plus maximum wind loading encountered at the installation site if the pan-tilt is to be mounted outdoors. Provide pan-tilt with:
  - (1) Heavy duty bearings
  - (2) Hardened steel gears
  - (3) Externally adjustable limit stops for pan and tilt
  - (4) Mechanical, dynamic, or friction brakes
  - (5) Permanent lubrication
  - (6) Motors that are thermally or impedance protected against overload damage.
- b. Provide pan movement of 360 degrees pan rotation, a minimum tilt movement of plus and minus 90 degrees. Manual pan speed must be a minimum of 0 to 80 degrees per second, and a minimum tilt speed of 10 degrees per second. A minimum automatic pan speed of 280 degree per second and tilt speed of 160 degree per second.
- c. The pan-tilt is to be supplied complete with wiring, wiring harnesses, connectors, receiver-driver, pan-tilt control system, pre-position cards, or any other hardware and equipment as needed to provide a fully functional pan-tilt mount to fulfill the site design requirements.

#### 2.5.1.3.9 Explosion Proof Housing

Not used.

#### 2.5.2 Thermal Imaging System

Not used.

#### 2.5.3 Video Analytics (VA)

##### 2.5.3.1 Software

Provide capability range from basic activity detection to the search through databases to pre-empt serious incidents. The VA is to provide graphic identified movement identification, user-selectable monitored areas, compensation for environmental movement, and other features specified when provided as a capability of the NVR. Provide the following features:

##### 2.5.3.1.1 Basic Motion Detection

- a. Adaptive Motion
- b. Abandoned Object
- c. Object Removal
- d. Camera Sabotage
- e. Directional Motion
- f. Object Counting
- g. Loitering Detection
- h. Stopped Vehicle

##### 2.5.3.1.2 Advanced VA

##### 2.5.3.1.2.1 Intruder Identification

This refers to identifying unauthorized humans in specified areas within the field of view.

##### 2.5.3.1.2.2 Environmental Compensation

Recognizing and ignoring wind-blown debris, animals, background traffic, and so on.

##### 2.5.3.1.2.3 Counting

This refers to recognizing a quantity of a particular object moving or activity performed.

##### 2.5.3.1.2.4 Directional Identification

This refers to the ability to ignore objects moving in one direction, while alarming for objects moving in unauthorized directions.

#### 2.5.3.1.2.5 Item Recognition

This refers to activation when specific user-selected items are removed from, placed in, or passed through the field of view.

#### 2.5.3.1.2.6 Subject Tracking

Highlighting and following a specific person or item as it moves about the field of view, or from the field of view of one camera to another.

#### 2.5.3.1.2.7 Multiple Subject Tracking

Highlighting and following multiple persons or items simultaneously as they move about the field of view, or from the field of view of one camera to another.

### 2.5.3.2 Embedded VA

#### 2.5.3.2.1 Intelligent Video Analysis

- a. Provide camera capable of processing and analyzing video within the camera itself, with no extra hardware required.
- b. The camera is to be capable of detecting and sending alarms for abnormal events.
- c. The camera is to be configurable to analyze up to 10 different scenes for one or more of the following events:
  - (1) Line Crossing
  - (2) Loitering
  - (3) Idle Object
  - (4) Removed Object
  - (5) Conditional Change
  - (6) Trajectory Tracking
  - (7) Filters
- d. The camera is to allow users to set up to 10 separate profiles and switch profiles based on a day, night, or holiday schedule.
- e. The camera is to support scene tours that automatically reposition the camera to each scene for a specified duration.
- f. The camera is to incorporate an Alarm Rule Engine, enabling abnormal events that VA detects to prompt the camera to take one or more actions:
  - (1) Trigger a relay connected to an alarm siren, strobe, or both.
  - (2) Trigger a visual alert to be displayed on the operator's screen.
  - (3) Go to a specified scene (preset position).

#### 2.5.3.2.2 Motion Tracking with PTZ Cameras

- a. The camera is to offer Intelligent Tracking to continuously track an object using pan, tilt, and zoom actions.
- b. The camera is to provide automatic motion tracking using intelligent video analytics.
- c. Provide camera with the ability to follow an object continually when passing behind a privacy mask.
- d. Provide camera with the ability to restart tracking if a target starts moving in the same area where the initial target stopped moving or if the camera detects an object moving along the last known trajectory.
- e. The camera is to allow an operator to select an object to track in the live image view.

#### 2.5.4 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.

##### 2.5.4.1 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.

#### 2.5.4.2 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.

#### 2.5.5 Ancillary Equipment

Equipment is to consist of the items specified below:

##### 2.5.5.1 Video Date and Time Generator

The video time and date is to originate from either the camera, video, video recorder, or time server.

##### 2.5.5.2 Camera Identifiers

Label video signal from each camera using alphanumeric identifiers. Camera alphanumeric identifiers may originate from either the camera or the video recorder.

##### 2.5.5.3 Video Recording

###### 2.5.5.3.1 Digital Video Recorder (DVR)

Not used.

###### 2.5.5.3.2 Hybrid Video Recorder (HVR)

Not used.

###### 2.5.5.3.3 Network Video Recorder (NVR)

- a. Provide NVR with an integral software ESS-CCTV server function. Dedicated CCTV 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 14 days of video at 15 fps, 2.1 megapixel resolution and be expandable for an increased capacity of 8 GB and be capable of including Redundant Array of Independent Disc (RAID) arrays 1.
- d. The NVR must have the capacity to address and process up to 16 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 2 weeks.

#### 2.5.5.3.4 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 16 channel triplex video multiplexer capable of performing encoding, recording and multiscreen viewing modes simultaneously. Provide 16 channels of live, simultaneous video images in which all channels are refreshed at 30 frames per second.
- c. Provide a 1000Base-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.
- 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 email 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 30 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 8 TB of digital video storage on a single partition.

The video recording system is to provide a choice of Physical Partitioning as RAID 1 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 16 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, 16 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 10-100-1000Base-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 1000Base-T connection. Permit direct camera selection for recording playback of any of 16 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.

#### 2.5.5.4 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)

#### 2.5.6 Camera Mounting Structures

Provide camera mounting structures designed specifically for CCTV 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. Allowable pole deflection is determined from the point of the camera mount and must not exceed 0.5 percent of the pole height under adjusted maximum wind load conditions. Adjusted maximum wind load conditions for deflection calculations must be 30 miles per hour (mph) or 35 percent of the basic wind speed as determined by TIA-222, whichever is greater. Confirm compliance to TIA standards by structure manufacturer data or by analysis. Provide additional measures as required to stabilize the camera if placed in an environment that is subject to induced vibrations such as heavy winds or excessive traffic.

## 2.6 SECURITY COMMAND CENTER (SCC)

The SCC must integrate all 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

### 2.6.1 ESS Software

- a. Provide commercial off-the-shelf ESS software that utilizes a single database for the subsystem integrations provided under a single operating environment. 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 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 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.
- e. Provide de-warping software for panoramic cameras.

#### 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 CCTV system interface
- b. Triggering NVR event recording
- c. Activating output devices
- d. Playing PC audio files

e. Controlling doors

f. 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 integrated 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 as part of the ESS integration.

##### 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 30 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 Excel 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 23 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 4 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. CCTV 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 wired network (RJ45) 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

Not used.

### 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 shielded cable 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. 16 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 10.24 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	10.24 kilobaud
Maximum loss at 1000 Hz	33 dB

#### 2.7.3 Radio Frequency Link

Not used.

#### 2.7.4 Data Encryption

Incorporate data encryption equipment on data transmission circuits as shown on the drawings. The algorithm used for encryption must be the Advanced Encryption Standard (AES) algorithm described in NIST FIPS 197 of ASC/X9 X9.52, as a minimum. Data encryption must be in accordance with NIST FIPS 140-2.

#### 2.7.5 Network Switch

Not used.

#### 2.7.6 Video and ESS Transmission

Transmission is to be by optical fiber dedicated to the associated circuit. Video and ESS transmission cables must conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM and Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

Install interior cable in Electrical Metallic Tubing (EMT) conduit unless indicated otherwise. Cable is to be rated for the installation method intended. Install exterior cable underground installed in Schedule 40 Polyvinyl chloride (PVC) conduits.

#### 2.7.7 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.

#### 2.7.8 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.

#### 2.7.9 Aboveground Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware. Provide multiconductor wire with a PVC outer jacket.

#### 2.7.10 Direct Burial Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware.

#### 2.7.11 Local Area Network (LAN) Cabling

Cabling must be in accordance with TIA-568.2-D, Category 6.

#### 2.7.12 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 SECURITY LIGHTING INTERFACE

Not used.

### 2.9 MEDICAL FACILITY SYSTEM

Not used.

### 2.10 SURVEILLANCE AND DETECTION EQUIPMENT

Not used.

### 2.11 BACKUP POWER

#### 2.11.1 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.

## 2.12 SURGE SUPPRESSION DEVICES

Comply with requirements in Section 33 82 00 TELECOMMUNICATION OUTSIDE PLANT (OSP).

## 2.13 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

### 2.13.1 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.

### 2.13.2 Exterior Sensor

Provide sensors to be used in an exterior environment with a housing that provides protection against windblown dust, rain and splashing water, and hose directed water. Sensors are not to be damaged by the ice formation on the enclosure. Refer to paragraph "Exposed-to-Weather Enclosures" and "Corrosion-Resistant Enclosures" for enclosure ratings.

### 2.13.3 Interior Enclosures

Enclosures to house equipment in an interior environment must meet the requirements of NEMA 250 Type 1.

### 2.13.4 Exposed-to-Weather Enclosures

Enclosures to house equipment in an outdoor environment must meet the requirements of NEMA 250 Type 4X.

### 2.13.5 Corrosion-Resistant Enclosures

Enclosures to house equipment in a corrosive environment must meet the requirements of NEMA 250 Type 4X.

#### 2.13.6 Hazardous Environment Equipment

All system electronics to be used in a hazardous environment must be housed in a metallic enclosure which meets the requirements of paragraph "Hazardous Locations."

#### 2.13.7 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.

#### 2.13.8 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.

#### 2.13.9 Ventilation

Ventilation openings in enclosures and cabinets must conform to requirements of [UL 1610](#).

#### 2.13.10 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.

#### 2.13.11 Labels

Label boxes containing connections that they contain ESS connections and indicate that the box is part of the ESS system.

#### 2.13.12 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.

### 2.14 [EQUIPMENT RACK](#)

#### 2.14.1 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.

## 2.15 LOCKS AND KEY LOCK

### 2.15.1 Lock

Provide locks on system enclosures for maintenance purposes that meet [UL 437](#) and are conventional key type lock having a five cylinder pin and five-point three position side bar combination. 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.

### 2.15.2 Key-Lock Operated Switches

All key-lock-operated switches required to be installed on system components are to be [UL 437](#), conventional key type lock having a five cylinder pin and five-point three position side bar combination. 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.

### 2.15.3 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.

## 2.16 FIELD FABRICATED NAMEPLATES

Nameplates must comply with [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 is to identify the function and, when applicable, the position.

Nameplates are to be melamine plastic, [0.125 inch](#) thick, white with black center core. Surface is to be matte finish. Corners are to be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be [1 by 2.5 inches](#). Provide lettering a minimum of [0.25-inch](#) high normal block style. Nameplates are not be required for devices smaller than [1 x 3 inches](#).

### 2.16.1 Manufacturer's Nameplate

Each item of equipment is to 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.

## 2.17 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 and [ICS 705-1](#). Install exterior conduits in accordance with [NFPA 70](#), Section [33 71 02](#) UNDERGROUND ELECTRICAL DISTRIBUTION and [ICS 705-1](#).

### 3.1.8 Underground Cable Installation

Install underground conductors connecting protected structures and objects to the central alarm updating and display unit as direct burial or in conduit as specified in Section [33 71 02](#) UNDERGROUND ELECTRICAL DISTRIBUTION. Coaxial cable cannot be spliced.

### 3.1.9 Exterior Fences

Not used.

### 3.1.10 Camera Housings, Mounts, and Poles

- a. Provide a foundation for each camera pole as specified and designed.
- b. Provide a ground rod for each camera pole and connect the camera pole to the ground rod as shown on the drawings.

### 3.1.11 Field Applied Painting

Not used.

## 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. 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 up to 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) One 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. CCTV 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 CCTV 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) One (one-day) 4-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. CCTV Operator Training includes:

- (1) One (one-day) 4-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 4- 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

#### PART 1 GENERAL

##### 1.1 RELATED SECTIONS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, 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 13.00 20 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION

Section 21 22 00.00 40 CLEAN AGENT FIRE EXTINGUISHING SYSTEMS

Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS

Section 08 71 00 DOOR HARDWARE for door release and additional work related to finish hardware.

Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

##### 1.2 SUMMARY

###### 1.2.1 Scope

- a. This work includes completion of design and providing a new, complete fire alarm and mass notification system as described herein and on the contract drawings for the KAFB Combat Rescue Helicopter Simulator Facility. Include in the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, alarm, and supervisory signal initiating devices, alarm notification appliances, supervising station fire alarm system transmitter, and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation.
- b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with the required provisions of NFPA 72, ISO 7240-16, IEC 60268-16, except as modified herein. The system layout on the drawings show the intent of coverage and are shown in suggested locations. Submit plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, wire counts, circuit identification in each conduit, and circuit layouts for all floors. Drawings shall comply with the requirements of NFPA 170. Final quantity, system layout, and coordination are the responsibility of the Contractor.

##### 1.3 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 (2009; R 2014) 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

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60268-16 (2003; ED 4.0) Sound System Equipment -  
Part 16: Objective Rating Of Speech  
Intelligibility By Speech Transmission  
Index

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 7240-16 (2007) Fire Detection And Alarm Systems -  
Part 16: Sound System Control And  
Indicating Equipment

ISO 7240-19 (2007) Fire Detection and Alarm Systems -  
Part 19: Design, Installation,  
Commissioning and Service of Sound Systems  
for Emergency Purposes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA  
20-1; TIA 20-2; TIA 20-3; TIA 20-4)  
National Electrical Code

NFPA 72 (2019; TIA 19-1; ERTA 2019) National Fire  
Alarm and Signaling Code

NFPA 90A (2018) Standard for the Installation of  
Air Conditioning and Ventilating Systems

NFPA 170 (2018) Standard for Fire Safety and  
Emergency Symbols

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-600-01 (2016; with Change 3, 2019) Fire  
Protection Engineering for Facilities

UFC 3-601-02 (2010) Operations and Maintenance:  
Inspection, Testing, and Maintenance of  
Fire Protection Systems

UFC 4-021-01 (2008; with Change 1, 2010) Design and  
O&M: Mass Notification 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 Jul 2016) UL Standard for  
Safety Smoke Detectors for Fire Alarm  
Systems

UL 464 (2016; Reprint Sep 2017) UL Standard for  
Safety Audible Signaling Devices for Fire  
Alarm and Signaling Systems, Including  
Accessories

UL 864 (2014; Reprint Mar 2018) UL Standard for  
Safety Control Units and Accessories for  
Fire Alarm Systems

UL 1283 (2017) UL Standard for Safety  
Electromagnetic Interference Filters

UL 1449 (2014; Reprint Jul 2017) 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 Electrical Construction (2012) Electrical Construction Equipment  
Directory

UL Fire Prot Dir (2012) Fire Protection Equipment Directory

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the

equipment, devices, and functions shall 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 Remote Fire Alarm Control Unit and Mass Notification Autonomous Control Unit

A control panel, electronically remote from the fire alarm and mass notification control panel, 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 control panel.

#### 1.4.3 Fire Alarm Control Unit and Mass Notification Autonomous Control Unit (FMCP)

A master control panel having the features of a fire alarm and mass notification control unit and fire alarm and mass notification control units are interconnected. The panel has central processing, memory, input and output terminals, and LCD.

#### 1.4.4 Local Operating Console (LOC)

A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery or recorded and/or live messages, initiate strobe and textural visible appliance operation and other related functions.

#### 1.4.5 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door that terminal strips are securely mounted.

### 1.5 SUBMITTALS

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

#### SD-02 Shop Drawings

Nameplates

Wiring Diagrams

System Layout; G

System Operation; G

Notification Appliances; G

Amplifiers; G



SD-03 Product Data

Technical Data and Computer Software; G  
Terminal Cabinets  
Manual Stations  
Transmitters (including housing)  
Batteries  
Battery Chargers  
Smoke Sensors; G  
Notification Appliances  
Addressable Interface Devices  
Amplifiers  
Tone Generators  
Digitalized Voice Generators  
Remote Fire Alarm/Mass Notification Control Units; G  
Radio Transmitter and Interface Panels; G  
Local Operating Console (LOC); G

SD-05 Design Data

Battery Power  
Battery Chargers

SD-06 Test Reports

Field Quality Control  
Testing Procedures; G  
Smoke Sensor Testing Procedures; G

SD-07 Certificates

Installer; G  
Qualified Fire Protection Engineer (QFPE); G  
Formal Inspection and Tests; G  
Final Testing; G

SD-09 Manufacturer's Field Reports

System Operation

Fire Alarm/Mass Notification System

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions

Instruction of Government Employees

SD-11 Closeout Submittals

As-Built Drawings; G

1.6 TECHNICAL DATA AND COMPUTER SOFTWARE

Technical data and computer software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES. Identify data delivered by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

- a. Identification of programmable portions of system equipment and capabilities.
- b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.
- c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.
- d. Description of Fire Alarm and Mass Notification Control Panel equipment operation.
- e. Description of auxiliary and remote equipment operations.
- f. Library of application software.
- g. Operation and maintenance manuals.

1.7 QUALITY ASSURANCE

Equipment and devices shall be compatible and operable with existing station fire alarm system and shall not impair reliability or operational functions of existing supervising station fire alarm system.

- a. Air Force Civil Engineer Support Agency.
- b. The recommended practices stated in the manufacturer's literature or documentation shall be considered as mandatory requirements.
- c. Devices and equipment for fire alarm service must be listed by **UL Fire Prot Dir** or approved by **FM APP GUIDE**.

### 1.7.1 Qualifications

#### 1.7.1.1 Design Services

Installations requiring completion of installation drawings and specification or modifications of fire detection, fire alarm, mass notification system, fire suppression systems or mass notification systems shall require the services and review of a [Qualified Fire Protection Engineer \(QFPE\)](#). For the purposes of meeting this requirement, a qualified engineer is defined as an individual meeting the following conditions:

- a. A registered professional engineer having a Bachelor of Science or Master of Science Degree in Fire Protection Engineering 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.

#### 1.7.1.2 Supervisor

NICET Fire Alarm Technicians to perform the installation of the system. A NICET Level IV Fire Alarm Technician shall supervise the installation of the fire alarm system/mass notification system. The Fire Alarm technicians supervising the installation of equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

#### 1.7.1.3 Technician

Fire Alarm Technicians with a minimum of four years of experience utilized to install and terminate fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings. Drawings, shop drawings, calculations, other required preconstruction documentation, and as-built drawings must be prepared by, or under the direct supervision of a NICET Level IV engineering technician. The QFPE must review the shop drawings, calculations, and material submittals. The shop drawings must bear the review stamp of the QFPE prior to submitting shop drawings to the AHJ.

#### 1.7.1.4 [Installer](#)

Fire Alarm installer with a minimum of two years of experience utilized to assist in the installation of fire alarm/mass notification devices, cabinets and panels. An electrician shall be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. The Fire Alarm installer shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

#### 1.7.1.5 Test Personnel

Fire Alarm Technicians with a minimum of eight years of experience (NICET Level IV) utilized to test and certify the installation of the fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians testing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

#### 1.7.1.6 Manufacturer

Components shall be of current design and shall 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 otherwise or additionally specified herein.

#### 1.7.2 Regulatory Requirements

##### 1.7.2.1 Requirements for Fire Protection Service

Equipment and material shall have been tested by UL and listed in UL Fire Prot Dir or approved by FM and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, they shall mean listed in UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement. All listings or approval by testing laboratories shall be from an existing ANSI or UL published standard.

##### 1.7.2.2 Fire Alarm/Mass Notification System

Furnish equipment that is compatible and is UL listed, FM approved, or listed by a nationally recognized testing laboratory for the intended use. All listings by testing laboratories shall be from an existing ANSI or UL published standard. Submit a unique identifier for each device, including the control panel and initiating and indicating devices, with an indication of test results, and signature of the factory-trained technician of the control panel manufacturer and equipment installer. With reports on preliminary tests, include printer information. Include the NFPA 72 Record of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

##### 1.7.2.3 Fire alarm Testing Services or Laboratories

Construct fire alarm and fire detection equipment in accordance with UL Fire Prot Dir, UL Electrical Construction, or FM APP GUIDE.

#### 1.8 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

### PART 2 PRODUCTS

#### 2.1 MATERIALS AND EQUIPMENT

Submit annotated catalog data as required in the paragraph SUBMITTAL, in table format on the drawings, showing manufacturer's name, model, voltage, and catalog numbers for equipment and components. Submitted shop drawings shall not be smaller than ISO A1. Also provide UL or FM listing cards for equipment provided.

##### 2.1.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory, such as UL or FM Approvals, LLC

(FM), and listed or approved 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 shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

#### 2.1.2 Nameplates

Major components of equipment shall 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 plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

- a. FMCPs, NACs, AMPs, LOCs
- b. Automatic transmitter/transceiver
- c. Terminal Cabinet

Furnish nameplate illustrations and data to obtain approval by the Contracting Officer before installation. Obtain approval by the Contracting Officer for installation locations. Nameplates shall be etched metal or plastic, permanently attached by screws to panels or adjacent walls.

#### 2.1.3 Keys

Keys and locks for equipment shall be identical. Provide not less than six keys of each type required. Master all keys and locks to a single key as required by the Installation Fire Department.

LOC is not permitted to be locked or lockable.

### 2.2 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment shall be listed for use under the applicable reference standards. Interfacing of Listed UL 864 or similar approved industry listing with Mass Notification Panels listed to UL 2017 shall be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control. If a field modification is needed, such as adding equipment like relays, the manufacturer of the panels being same or different brand from manufacturer shall provide the installing contractor for review and confirmation by the installing contractor. As part of the submittal documents, provide this information.

### 2.3 SYSTEM OPERATION

The Addressable Interior Fire Alarm and Mass Notification System shall be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864, and UL 2017. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until the initiating device is reset and the control panel is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, or remotely from authorized locations/users.

Submit data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances, 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings. Submit a complete description of the system operation in matrix format on the drawings. Submit a complete list of device addresses and corresponding messages.

#### 2.3.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice, Textural)

- a. Connect alarm initiating devices to initiating device circuits (IDC) Class "B" installed in accordance with NFPA 72.
- b. Connect alarm notification appliances and speakers to notification appliance circuits (NAC) Class "B".
- c. The system shall operate in the alarm mode upon actuation of any alarm initiating device or a mass notification signal. The system shall remain in the alarm mode until initiating device(s) or mass notification signal is/are reset and the control panel is manually reset and restored to normal. Audible, and visual appliances and systems shall comply with NFPA 72 and as specified herein. Fire alarm system/mass notification system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc.

#### 2.3.2 Functions and Operating Features

The system shall provide the following functions and operating features:

- a. The FMCP shall provide power, annunciation, supervision, and control for the system. Addressable systems shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.
- b. For Class "B" circuits with conductor lengths of 10 feet or less, the conductors shall be permitted to be installed in the same raceway in accordance with NFPA 72.
- c. Provide notification appliance circuits. The visual alarm notification appliances shall have the flash rates synchronized as required by NFPA 72.
- d. Provide electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control panel.
- e. Provide an audible and visual trouble signal to activate upon a single break or open condition, or ground fault (or short circuit for Class "B"). The trouble signal shall also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory panel modules. Provide a trouble alarm silence feature that shall silence the audible trouble signal, without affecting the visual indicator. After the system returns to normal operating conditions, the trouble signal shall again sound until the trouble is acknowledged. A smoke sensor in the process of being verified for the actual presence of smoke shall not initiate a trouble condition.

- f. Provide program capability via switches in a locked portion of the FACP to bypass the automatic notification appliance circuits, air handler shutdown, door release, and door unlocking features. Operation of this programming shall indicate this action on the FACP display and printer output.
- g. Alarm, supervisory, and/or trouble signals shall be automatically transmitted to the base receiving station.
- h. Alarm functions shall override trouble or supervisory functions. Supervisory functions shall override trouble functions.
- i. The system shall be capable of being programmed from the panels keyboard. Programmed information shall be stored in non-volatile memory.
- j. The system shall be capable of operating, supervising, and/or monitoring both addressable and non-addressable alarm and supervisory devices.
- k. There shall be no limit, other than maximum system capacity, as to the number of addressable devices, that may be in alarm simultaneously.
- l. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system, such as an HVAC system or a releasing panel, the addressable fire alarm relay shall be in the vicinity of the emergency control device.
- m. An alarm signal shall automatically initiate the following functions:
  - (1) Transmission of an alarm signal to the base receiving station.
  - (2) Visual indication of the device operated on the control panel (FACP/MNCP), LCD, and on the graphic annunciator. Indication on the graphic annunciator shall be by floor, zone or circuit, and type of device.
  - (3) Continuous actuation of all alarm notification appliances.
  - (4) Recording of the event via electronically in the history log of the fire control system unit.
  - (5) Release of doors held open by electromagnetic devices.
  - (6) Release of power to electric locks (delayed egress locks) on doors that are part of the means of egress unless specifically required to remain locked and operable from the inside only without authorized access.
  - (7) Operation of a duct smoke sensor shall shut down the appropriate air handler and initiate a supervisory alarm signal in accordance with NFPA 90A in addition to other requirements of this paragraph and as allowed by NFPA 72.
- n. A supervisory signal shall automatically initiate the following functions:
  - (1) Visual indication of the device operated on the FACP, and on the graphic annunciator and sound the audible alarm at the respective

panel.

- (2) Transmission of a supervisory signal to the base receiving station.
- (3) Recording of the event electronically in the history log of the control unit.
- o. A trouble condition shall automatically initiate the following functions:
  - (1) Visual indication of the system trouble on the FACP and on the remote annunciator and sound the audible alarm at the respective panel.
  - (2) Transmission of a trouble signal to the base receiving station.
  - (3) Recording of the event in the history log of the control unit.
- p. The maximum permissible elapsed time between the actuation of an initiating device and its indication at the FACP is 10 seconds.
- q. The maximum elapsed time between the occurrence of the trouble condition and its indication at the FACP is 200 seconds.
- r. Activation of a LOC pushbutton shall activate the audible and visual alarms in the facility. The audible message shall be the one associated with the pushbutton activated.

## 2.4 SYSTEM MONITORING

### 2.4.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, standpipe control valves, sprinkler service entrance valve, valves at fire pumps, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, shall be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address, unless they are within the same room, then a maximum of five can use the same address.

### 2.4.2 Independent Fire Detection System

Each existing independent smoke detection subsystem and releasing system (e.g. clean agent extinguishing system) shall be monitored both for the presence of two alarm conditions as well as a trouble condition. Provide each monitored condition with a separate address.

## 2.5 MASS NOTIFICATION SYSTEM FUNCTIONS

### 2.5.1 Notification Appliance Network

The audible notification appliance network consists of speakers located to provide intelligible instructions at areas as indicated. The Mass Notification System announcements shall take priority over all other audible announcements of the system including the output of the fire alarm system in a normal or alarm state. When a mass notification announcement is activated during a fire alarm, all fire alarm system functions shall continue in an alarm state except for the output signals of the fire alarm



audible and visual notification appliances.

#### 2.5.2 Strobes

Provide strobes per NFPA 72, UFC 3-600-01, UFC 4-021-01 and ADA to alert hearing-impaired occupants.

#### 2.5.3 Text Displays

LED text displays (textural visible appliances) for hearing impaired occupants. The textual displays shall be programmable and shall display the same content of the voice message being played. The signs shall be able to provide a minimum of 4-inch-high letters and be located in high traffic areas easily seen by building occupants. The system shall interface with the Programmable sign controller to activate the proper message.

#### 2.5.4 Wide Area MNS

The Wide Area MNS system (if available) in the area of the building shall not be activated by the in-building MNS.

#### 2.5.5 Voice Notification

An autonomous voice notification control unit is used to monitor and control the notification appliance network and provide consoles for local operation. Using a console, personnel in the building can initiate delivery of pre-recorded voice messages, provide live voice messages and instructions, and initiate visual strobe and optional textual message notification appliances. The autonomous voice notification control unit will temporarily override audible fire alarm notification while delivering Mass Notification messages to ensure they are intelligible.

### 2.6 OVERVOLTAGE AND SURGE PROTECTION

#### 2.6.1 Circuit Surge Protection

Provide surge suppression for all signaling line circuits, indicating device circuits, or notification appliances circuits that leave or enter the Facilities exterior enclosure. Provide surge suppression on all 120 VAC circuits to control panels, subpanels, transmitters, amplifier panels, and booster panels. Surge suppression must have both a UL 1449 and UL 1283 listing and must be located in an adjacent hinged terminal box. Surge suppression shall comply with the applicable requirements of IEEE C62.41.1 and IEEE C62.41.2.

#### 2.7 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored shall be configured as a Class "B" initiating device circuits. The system shall 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, etc. The module shall be UL or FM listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall 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.

## 2.8 ADDRESSABLE CONTROL MODULE

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems, and to control door holders or initiate elevator fire service. The module shall be UL or FM listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Class "B" notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control model shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules shall be located in environmental areas that reflect the conditions to which they were listed.

## 2.9 ISOLATION MODULES

Provide isolation modules to subdivide each signaling line circuit into groups of not more than 20 addressable devices between adjacent isolation modules.

## 2.10 SMOKE SENSORS

### 2.10.1 Photoelectric Smoke Sensors

Provide addressable photoelectric smoke sensors as follows:

- a. Provide analog/addressable photoelectric smoke sensors utilizing the photoelectric light scattering principle for operation in accordance with [UL 268](#). Smoke sensors shall be listed for use with the fire alarm control panel.
- b. Provide self-restoring type sensors that do not require any readjustment after actuation at the FACP to restore them to normal operation. Sensors shall be UL listed as smoke-automatic fire sensors.
- c. Components shall be rust and corrosion resistant. Vibration shall have no effect on the sensor's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen shall not inhibit the movement of smoke particles into the chamber.
- d. Provide twist lock bases. The sensors shall maintain contact with their bases without the use of springs. Provide companion mounting base with screw terminals for each conductor. Terminate field wiring on the screw terminals. The sensor shall have a visual indicator to show actuation.
- e. The sensor address shall identify the particular unit, its location within the system, and its sensitivity setting. Sensors shall be of the low voltage type rated for use on a 24 VDC system.
- f. An operator at the control panel, having a proper access level, shall

have the capability to manually access the following information for each initiating device.

- (1) Primary status
- (2) Device type
- (3) Present average value
- (4) Present sensitivity selected
- (5) Sensor range (normal, dirty, etc.)

#### 2.10.2 Duct Smoke Sensors

Duct-mounted photoelectric smoke detectors shall be furnished and installed where indicated and in accordance with NFPA 90A. Units shall consist of a smoke detector as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. (It is not permitted to cut the duct insulation to install the duct detector directly on the duct). Detectors shall have a manual reset. Detectors shall be rated for air velocities that include air flows between 500 and 4000 fpm. Detectors shall be powered from the fire alarm panel. Air handling units that serve a space that has detection throughout the space and serve no other spaces are not required to have duct smoke detection per UFC 3-600-01.

- a. Sampling tubes shall run the full width of the duct. The duct detector package shall conform to the requirements of NFPA 90A, UL 268 A, and shall be UL listed for use in air-handling systems. The control functions, operation, reset, and bypass shall be controlled from the fire alarm control panel. Test and reset switches as accessible and no more than 86 inches AFF.
- b. Lights to indicate the operation and alarm condition; and the test and reset buttons shall be visible and accessible with the unit installed and the cover in place. Remote indicators shall be provided where required by NFPA 72 and these shall be provided with test and reset switches.
- c. Remote lamps and switches as well as the affected fan units shall be properly identified in etched plastic placards. Detectors shall provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Auxiliary contacts provide for this function shall be located within 3 feet of the controlled circuit or appliance. The detectors shall be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

#### 2.10.3 Air Sampling Smoke Detectors

Air sampling detectors are early warning devices used to detect what may be the beginning of a fire. The detector uses a series of perforated pipes in the protected area to continuously draw smoke into the sampling chamber. Once in the sampling chamber the air is sampled by cloud density measuring to determine if there is possibly a fire in the protected area. These units shall be programmable in multiple levels to indicate detection of particles that are not normally present, to indicate the presence of

particle that could be produced by a fire and to indicate the presence of particles of the proper size and quantity to indicate that a fire conditions exists. Air sampling detectors shall be capable of providing two alert conditions and two alarm conditions. The building fire alarm system shall monitor all alert and alarm conditions.

#### 2.10.4 Smoke Sensor Testing

Smoke sensors shall be tested in accordance with NFPA 72 and manufacturer's recommended calibrated test method. Submit smoke sensor testing procedures for approval. In addition to the NFPA 72 requirements, smoke detector sensitivity shall be tested during the preliminary tests.

### 2.11 ELECTRIC POWER

#### 2.11.1 Primary Power

Power shall be 120 VAC service for the FACP from the AC service to the building in accordance with NFPA 72. A 20-amp VAC dedicated circuit shall be provided. Circuit shall be capable of being locked. Dedicated circuits shall be provided for the clean agent releasing panels (CARPs) and the air sampling detector units.

### 2.12 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 shall be automatic and shall not cause transmission of a false alarm.

#### 2.12.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FMCP. Batteries shall contain suspended electrolyte. The battery system shall 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.

##### 2.12.1.1 Capacity

Battery size shall be the greater of the following two capacities.

- a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 24 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.

##### 2.12.1.2 Battery Power Calculations

- a. Verify that battery capacity exceeds supervisory and alarm power requirements.
  - (1) Substantiate the battery calculations for alarm, alert, and supervisory power requirements. Include ampere-hour requirements for each system component and each panel component, and compliance

with UL 864.

- (2) Provide complete battery calculations for both the alarm, alert, and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.
  - (3) A voltage drop calculation to indicate that sufficient voltage is available for proper operation of the system and all components, at the minimum rated voltage of the system operating on batteries.
- b. For battery calculations use the following assumptions: 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. Calculate the nominal battery voltage after operation on batteries for the specified time period. Using this voltage perform a voltage drop calculation for circuit containing device and/or appliances remote from the power sources.

#### 2.12.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger shall be capable of providing 120 percent of the connected system load and shall maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger shall 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.

#### 2.13 FIRE ALARM CONTROL UNIT AND MASS NOTIFICATION CONTROL UNIT (FMCP)

If required, provide a complete control panel fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care and maintenance of the systems shall be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control panel, the unit cabinets shall match exactly.

- a. Each control unit shall 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 shall be suitable for operation on a 120-volt, 60 hertz, normal building power supply. Provide each panel with supervisory functions for power failure, internal component placement, and operation.
- b. Visual indication of alarm, supervisory, or trouble initiation on the fire alarm control panel shall be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit shall 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 pre-recorded messages. Provide the ability to automatically repeat pre-recorded messages. Provide a secure microphone for delivering live messages. Provide adequate

discrete outputs to temporarily deactivate fire alarm audible notification and initiate/synchronize strobes. 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.

#### 2.13.1 Cabinet

Install control panel components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of panels as well as field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall say "Fire Alarm and Mass Notification Control Panel" and shall not be less than 1 inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet shall be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.

#### 2.13.2 Control Modules

Provide power and control modules to perform all functions of the FACP. Provide audible signals to indicate any alarm, supervisory, or trouble condition. The alarm signals shall be different from the trouble signal. Connect circuit conductors entering or leaving the panel to screw-type terminals with each terminal marked for identification. Locate diodes and resistors, if any, on screw terminals in the FACP. Circuits operating at 24 VDC shall not operate at less than the UL listed voltage at the sensor or appliance connected. Circuits operating at any other voltage shall not have a voltage drop exceeding 10 percent of nominal voltage

#### 2.13.3 Silencing Switches

##### 2.13.3.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCP that shall silence the audible and visual. This switch shall be overridden upon activation of a subsequent alarm.

##### 2.13.3.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch that shall silence the audible trouble and supervisory signal, but not extinguish the visual indicator. This switch shall be overridden upon activation of a subsequent alarm, supervision, or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated.

#### 2.13.4 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. Circuits shall be manually reset by switch from the FACP after the initiating device or devices have been restored to normal.

#### 2.13.5 Audible Notification System

The Audible Notification System shall comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements,

ISO 7240-16, IEC 60268-16, except as specified herein. The system shall be a one-way multi-channel voice notification system incorporating user select ability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of prerecorded messages. Audible appliances shall produce a temporal code 3 tone for three cycles followed by a voice message that is repeated until the control panel is reset or silenced. Automatic messages shall be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message shall override the automatic audible output through use of a microphone input at the control panel or the LOC.

- a. When using the microphone, live messages shall be broadcast throughout a selected floor or floors or all call. The system shall be capable of operating all speakers at the same time. The Audible Notification System shall support Public Address (PA) paging for the facility. The microprocessor shall 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 shall automatically cause the code 3 temporal tone to take over all functions assigned to the failed unit in the event an alarm is activated.
- b. The Mass Notification functions shall override the manual or automatic fire alarm notification or Public Address (PA) functions. Other fire alarm functions including transmission of a signal(s) to the fire department shall remain operational. The system shall have the capability of utilizing LOC with redundant controls of the notification system control panel. Notification Appliance Circuits (NAC) shall be provided for the activation of strobe appliances. The activation of the NAC Circuits shall follow the operation of the speaker NAC circuits. Audio output shall be selectable for line level. Amplifier outputs shall be not greater than 100 watts RMS output. The strobe NAC Circuits shall provide at least 2 amps of 24 VDC power to operate strobes and have the ability to synchronize all strobes. A handheld microphone shall be provided and, upon activation, shall take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC Circuits activation.

#### 2.13.5.1 Outputs and Operational Modules

All outputs and operational modules shall 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 panel shall not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

#### 2.13.5.2 Mass Notification

- a. Mass Notification functions shall take precedence over all other function performed by the Audible Notification System. Audibles must continue to sound for not less than 180 seconds in the following sequences (i.e. Alert sound followed by voice message) unless noted otherwise. Messages shall utilize a female voice and shall be similar to the following:

- (1) Alert Sound - NFPA Temporal 3 (T-3) - 422 - 775 Hz upward sweep over 850 ms for three-pluses each separated by 1 second followed by a 1.5 second delay (repeat 2 cycles). Announcement to follow alert sound, "May I have your attention please. May I have your attention please. A fire emergency occurred; please leave the building by the nearest exit." (Provide a 2 second pause and repeat message.)
- (2) Pre-TEST sound - NOAA Standard alert tone (8 seconds). Announcement to follow Pre-TEST sound, "Test, Test, Test, Test, this is an emergency notification audio system test; you may continue normal operations, test, test, test." (Provide a 2 second pause and repeat message.) Audibles for test messages permitted to terminate prior to 180 seconds.

- b. Include ALL installation specific message in this section.
- c. The LOC shall incorporate a Push-To-Talk (PTT) microphone, redundant controls and system status indicators of/for the system. The unit shall incorporate microphone override of any tone generation or prerecorded messages. The unit shall be fully supervised from the control panel. The housing shall contain a latch (not lock).
- d. Auxiliary Input Module shall be designed to be an outboard expansion module to either expand the number of optional LOCs or allow a telephone interface.
- e. LOC shall incorporate a Push-To-Talk (PTT) microphone, and controls to allow Public Address paging in the facility. The Public Address paging function shall not override any alarm or notification functions and shall be disabled by such signals. The microphone shall be handheld style. All wiring to the LOC shall be supervised in accordance with **UFC 4-021-01**. Systems that require field modification or are not supervised for multiple LOCs shall not be approved.
- f. When an installation has more than one LOC, the LOCs shall be programmed to allow only one LOC to be available for page or messaging at a time. Once one LOC becomes active, all other LOCs 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. Also, it must be possible to override or lockout the LOCs from the Master Command Panel (in accordance with **NFPA 72**.)

#### 2.13.6 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 shall not be considered as equal to non-volatile processors, PROMS, or EPROMS.

#### 2.13.7 Field Programmability

Provide control units and control panels that are fully field programmable for control, initiation, notification, supervisory, and trouble functions of both input and output. The system program configuration shall be menu driven. System changes shall be password protected and shall be accomplished using personal computer-based equipment. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as



part of this contract.

#### 2.13.8 Input/Output Modifications

The FMCP shall contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features shall consist of a panel mounted keypad. Any bypass or modification to the system shall indicate a trouble condition on the FMCP.

#### 2.13.9 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.

#### 2.13.10 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 instructions on the interior of the FACP. The card shall 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 shall be approved by the Contracting Officer before being posted.

#### 2.13.11 Walk Test

The FACP shall have a walk test feature. When using this feature, operation of initiating devices shall result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated on the system printer, but no other outputs occur.

#### 2.13.12 History Logging

In addition to the required printer output, the control panel shall have the ability to store a minimum of 400 events in a log. These events shall be stored in a battery-protected memory and shall remain in the memory until the memory is downloaded or cleared manually. Resetting of the control panel shall not clear the memory.

#### 2.13.13 Remote LCD Text Display

An LCD text display shall be provided at locations as shown on the drawings. The size shall not exceed 16 inches length by 3 inches deep with a height necessary to meet the requirements of Chapter 24 of NFPA 72. The text display shall as a minimum meet the following requirements:

- a. Two lines of information for high priority messaging.
- b. Minimum of 20 characters per line (40 total) displayed.
- c. Text shall be no less than height requirements in Table 24.4.2.20.14.5 of NFPA 72 and color/contrast requirements of 24.4.2.20 of NFPA 72.
- d. 32K character memory.
- e. Display shall be wall or ceiling mounted.
- f. Mounting brackets for a convenient wall/cubicle mount.

- g. During non-emergency periods, display date and time.
- h. All programming shall be accomplished from the Mass Notification network. No user programming shall be required.

An LCD text display shall be provided at locations as shown on the drawings. The LCD text display shall spell out the words "EVACUATE" and "ANNOUNCEMENT" and the remainder of the emergency instructions. The design of LCD text display shall be such that it cannot be read when not illuminated.

#### 2.14 REMOTE FIRE ALARM/MASS NOTIFICATION CONTROL UNITS

If required, provide complete remote-control units fully enclosed in a lockable steel enclosure as specified herein. Operations required for testing or for normal care and maintenance of the control units shall be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control panel, the unit enclosures shall match exactly. Each control unit shall provide power, supervision, control, and logic for its portion of the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit shall be suitable for operation on a 120-volt, 60 hertz, normal building power supply. Provide each unit with supervisory functions for power failure, internal component placement, and operation.

##### 2.14.1 Cabinet

Install remote control unit components in cabinets large enough to accommodate components and also to allow ample gutter space for interconnection of units as well as field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall be labeled "Remote Fire Alarm/Mass Notification Control Unit" and shall not be less than one inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet shall be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock (keyed the same as the FMCP), and surface mounting provisions.

##### 2.14.2 Control Modules

Provide power and control modules to perform all functions of the remote-control unit. Provide audible signals to indicate any alarm or trouble condition. The alarm signals shall be different from the trouble signal. Connect circuit conductors entering or leaving the panel to screw-type terminals with each terminal marked for identification. Locate diodes and relays, if any, on screw terminals in the remote-control unit. Circuits shall not have a voltage drop exceeding 10 percent of nominal voltage. Circuits shall be arranged so that there is 25 percent spare capacity for any circuit.

##### 2.14.3 Silencing Switches

Provide an alarm silencing switch at the remote-control unit that shall silence the audible signal and extinguish the visual alarms. This switch shall be overridden upon activation of a subsequent alarm. Provide trouble and supervisory silencing switch that shall silence the audible trouble and supervisory signal, but not extinguish the visual indicator.

This switch shall be overridden upon activation of a subsequent trouble or supervisory signal. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated.

#### 2.14.4 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. Circuits shall be manually resettable by switch from the remote-control unit after the initiating device or devices have been restored to normal.

#### 2.14.5 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 shall not be considered as equal to non-volatile processors, PROMS, or EPROMS.

#### 2.14.6 Field Programmability

Provide control units that are fully field programmable for control, initiating, supervisory, and trouble functions of both input and output. The system program configuration shall be menu driven. System changes shall be password protected and shall be accomplished using personal computer-based equipment. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

#### 2.14.7 Input/Output Modifications

Each remote-control unit shall contain features that allow the elimination of input devices from the system or the modification of system outputs. Any such modifications shall indicate a trouble condition on the remote-control unit, the FACP, and a printed output of the trouble condition.

#### 2.14.8 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.

#### 2.14.9 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. The card shall 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 shall be approved by the Contracting Officer before being posted.

#### 2.14.10 Walk Test

Each remote-control unit shall have a walk test feature. When using this feature, operation of initiating devices shall result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated on the system printer, but no other outputs occur.

#### 2.14.11 History Logging

In addition to the required printer output, the control panel shall have the ability to store a minimum of 1000 events in a log. These events shall be stored in a battery-protected memory and shall remain in the memory until the memory is downloaded or cleared manually. Resetting of the control panel shall not clear the memory.

#### 2.15 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 shall be housed in a remote panel, terminal cabinet, or in the FMCP. Submit data to indicate that the amplifiers have sufficient capacity to simultaneously drive all notification speakers at the maximum rating plus 50 percent spare capacity. Annotate data for each circuit on the drawings.

##### 2.15.1 Operation

The system shall automatically operate and control all building speakers except those installed in the stairs and within elevator cabs. The speakers in the stairs and elevator cabs shall operate only when the microphone is used to deliver live messages.

##### 2.15.2 Construction

Amplifiers shall utilize computer grade solid state components and shall 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.

##### 2.15.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and panel mounted microphone Public Address Paging Function (where allowed). Microphone inputs shall be of the low impedance, balanced line type. Both microphone and tone generator input shall be operational on any amplifier.

##### 2.15.4 Tone Generator

The tone generator shall be of the modular, plug-in type with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces. The tone generator shall produce a code 3 temporal tone and shall be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator shall 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 cause transfer of the common trouble relay.

##### 2.15.5 Protection Circuits

Each amplifier shall be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component shall cause automatic transfer to a designated backup amplifier, illumination of a visual "amplifier trouble" indicator on the control

panel, appropriate logging of the condition on the system printer, and other actions for trouble conditions as specified.

## 2.16 ANNUNCIATOR

### 2.16.1 Annunciator Panel

Provide an annunciator that includes an LCD display. The display shall indicate the device in trouble/alarm or any supervisory device. Display the device name, address.

A building floor plan shall be provided mounted (behind plexiglass or similar protective material) at the annunciator location. The floor plan shall indicate all rooms by name and number including the locations of stairs and elevators. The floor plan shall show all devices and their programmed address to facilitate their physical location from the LCD display information.

### 2.16.2 Programming

Where programming for the operation of the annunciator is accomplished by a separate software program than the software for the FMCP, the software program shall not require reprogramming after loss of power. The software shall be reprogrammable in the field.

## 2.17 MANUAL STATIONS

Provide metal or plastic, semi-flush mounted, double action, addressable manual stations, that are not subject to operation by jarring or vibration. Stations shall 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 shall be finished in fire-engine red with molded raised lettering operating instructions of contrasting color. The use of a key or wrench shall be required to reset the station. Manual stations shall be mounted at 44 inches. Stations shall have a separate screw terminal for each conductor.

## 2.18 NOTIFICATION APPLIANCES

### 2.18.1 Fire Alarm/Mass Notification Speakers

Audible appliances shall conform to the applicable requirements of UL 464. Appliances shall be connected into notification appliance circuits. Surface mounted audible appliances shall be painted white. Recessed audible appliances shall be installed with a grill that is painted white.

- a. Speakers shall conform to the applicable requirements of UL 1480. Speakers shall 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. Tap settings shall include taps of 1/8, 1/4, 1/2, 1, and 2 watts. Speakers shall incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 150 Hz to 10,000 Hz and shall have a sealed back construction. Speakers shall 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 wall mounted unit. All inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCP.

- b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gauge or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.
- c. Speakers shall utilize screw terminals for termination of all field wiring.

## 2.18.2 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and conform to the Architectural Barriers Act (ABA). Colored lens, such as amber, shall comply with UL 1638. Fire Alarm/Mass Notification Appliances shall have clear high intensity optic lens, xenon flash tubes, and be marked "Alert" in red letters. The light pattern shall be disbursed 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 shall be 1 flash per second and a minimum of 15 candela (actual output after derating for tinted lens) based on the UL 1971 test. Strobe shall be surface mounted. Where more than two appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices shall use screw terminals for all field wiring.

## 2.19 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures shall be provided to permit Fire Alarm or Mass Notification components to be used in areas that exceed the environmental limits of the listing. The enclosure shall be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the UL category that the component is currently listed. Guards required to deter mechanical damage shall be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance. All outdoor components shall be minimum NEMA 4X rated. No cabinets for panels, transmitters, or other equipment shall be installed in non-conditioned spaces, including main mechanical rooms.

## 2.20 INTERFACE TO THE BASE WIDE MASS NOTIFICATION NETWORK

### 2.20.1 Radio

The radio transceiver shall 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 shall 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 shall transmit a unique identity code as part of all messages; the code is set by the user at the transceiver.

#### 2.20.1.1 Radio Frequency Communications

Use of radio frequency-type communications systems shall comply with National Telecommunications and Information Administration (NTIA) requirements. Use of any radio frequency transmitting devices must be coordinated with the Installation Spectrum Manager prior to equipment use or purchase.

#### 2.20.1.2 Licensed Radio Frequency Systems

An approved DD Form 1494 for the system is required prior to operation.

#### 2.20.2 Telephone

A modem shall be provided for communication with the Central Control/Monitoring System. The modem shall be 56k, compatible with data mode V.90, utilizing Hayes compatible command codes. The modem shall be capable of Auto dialing a preset number based on preprogrammed events. The modem shall auto answer and provide a secure password protection system.

#### 2.20.3 Secure Radio System

##### 2.20.3.1 Communications Network

The communications network provides two-way signals between central control units and autonomous control units (in individual building systems) and should include redundant (primary and backup) communication links. The system shall incorporate technology to prevent easy interruption of the radio traffic for MNS Alerting.

##### 2.20.3.2 Radio Frequency Communications

Use of radio frequency-type communications systems shall comply with National Telecommunications and Information Administration (NTIA) requirements. The systems shall be designed to minimize the potential for interference, jamming, eavesdropping, and spoofing.

##### 2.20.3.3 Licensed Radio Frequency Systems

An approved DD Form 1494 for the system is required prior to operation.

#### 2.21 AUTOMATIC FIRE TRANSMITTERS

##### 2.21.1 Radio Transmitter and Interface Panels

Transmitters shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters shall 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 shall be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is Monaco and the transceiver shall be fully compatible with this equipment. The transmitter shall 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.

#### 2.21.1.1 Operation

Operate each transmitter from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

#### 2.21.1.2 Battery Power

Transmitter standby battery capacity shall 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.

#### 2.21.1.3 Transmitter Housing

Use NEMA Type 1 for housing. The housing shall contain a lock that is keyed identical to the fire alarm system for the building. Radio alarm transmitter housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

#### 2.21.1.4 Antenna

Antenna shall be omnidirectional antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall 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.

#### 2.21.2 Signals to Be Transmitted to the Base Receiving Station

The following signals shall be sent to the base receiving station:

- a. Sprinkler water flow (typical for all)
- b. Manual pull stations
- c. Smoke detectors
- d. Duct smoke detectors
- e. Aspirating Detection System Fire Condition - with unique addresses and descriptions
- f. Aspirating Detection System Alert Condition - Supervisory Signals with unique addresses and descriptions
- g. Clean Agent System Release - with unique addresses and descriptions
- h. System trouble conditions

#### 2.22 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein. NFPA 70 accepted fire alarm cables that do not require



the use of raceways except as modified herein are permitted.

#### 2.22.1 Alarm Wiring

The SLC wiring shall be solid copper cable in accordance with the manufacturer's requirements. Copper signaling line circuits and initiating device circuit field wiring shall be No. 18 AWG size twisted and shielded solid conductors at a minimum. Visual notification appliance and initiating device circuit conductors, that contain audible alarm appliances, shall be No. 16 AWG size conductors at a minimum. Wire size shall be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC shall not operate at less than the UL listed voltages for the sensors and/or appliances. Power wiring, operating at 120 VAC minimum, shall 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 shall comply with NFPA 70.

### PART 3 EXECUTION

#### 3.1 INSTALLATION OF FIRE ALARM INITIATING DEVICES AND NOTIFICATION APPLIANCES

##### 3.1.1 FMCP

As required, locate the FMCP 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 shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the FMCP.

##### 3.1.2 Manual Stations

Locate manual stations as required by NFPA 72 and as indicated on Contract Drawings. Mount stations so that their operating handles are 4 feet above the finished floor. Mount stations so they are located no farther than 5 feet from the exit door they serve, measured horizontally.

##### 3.1.3 Notification Appliance Devices

Locate notification appliance devices as required by NFPA 72. Mount assemblies on walls as required by NFPA 72 and to meet the intelligibility requirements. Ceiling mounted speakers shall conform to NFPA 72.

##### 3.1.4 Smoke Sensors

Locate sensors as required by NFPA 72 and their listings on a 4-inch mounting box. Locate smoke sensors on the ceiling. Smoke sensors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Smoke sensors under raised floor spaces, shall be air aspirating type and sample ports shall be one for no more than 225 square feet per sensor. Install spot smoke sensors no closer than 5 feet from air handling supply outlets.

##### 3.1.5 Annunciator

Locate the annunciator as shown on the drawings. Surface mount the panel, with the top of the panel 6 feet above the finished floor or center the panel at 5 feet, whichever is lower.

### 3.1.6 Water Flow Detectors and Tamper Switches

Connect input modules to water flow detectors and tamper switches. Provided under Section 21 13 13.00 10 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION.

### 3.1.7 Local Operating Console (LOC)

Locate the LOC as required by NFPA 72 and as indicated on Contract Drawings. Mount the console so that the top message button is no higher than 44 inches above the floor.

## 3.2 SYSTEM FIELD WIRING

### 3.2.1 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 shall 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. Conform wiring to 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 shall show connections from field devices to the FACP and remote fire alarm 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.

### 3.2.2 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 shall be appropriate for the size of the wiring to be connected. Conductor terminations shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted.

### 3.2.3 Alarm Wiring

Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Provide all wiring in electrical metallic conduit. Conceal conduit in finished areas of new construction and wherever practicable in existing construction. The use of flexible conduit not exceeding a 6-foot length shall be permitted in initiating device or notification appliance circuits. Run conduit or tubing (rigid, IMC, EMT, FMC, etc. as permitted by NFPA 72 and NFPA 70) concealed unless specifically indicated otherwise.

Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, that is in or adjacent to the FMCP. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. Color coding is required for circuits and shall be maintained throughout the circuit. Conductors used for the same functions shall be similarly color coded. Conform wiring to NFPA 70.

#### 3.2.4 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCP, and remote FMCP and the LOC shall be provided at each conductor connection. Each conductor or cable shall have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCP, and remote FMCP shall contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing shall be neat, using 12-point lettering minimum size, and mounted within each cabinet, panel, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

#### 3.3 DISCONNECTION AND REMOVAL OF EXISTING SYSTEM

As applicable, maintain existing fire alarm equipment fully operational until the new equipment has been tested and accepted by the Contracting Officer. As new equipment is installed, label it "NOT IN SERVICE" until the new equipment is accepted. Once the new system is completed, tested, and accepted by the Government, it shall be placed in service and connected to the station fire alarm system. Remove tags from new equipment and tag the existing equipment "NOT IN SERVICE" until removed from the building.

- a. After acceptance of the new system by the Contracting Officer, remove existing equipment not connected to the new system, remove unused exposed conduit, and restore damaged surfaces. Remove the material from the site and dispose.
- b. Disconnect and remove the existing fire alarm and smoke detection systems where indicated and elsewhere in the specification.
- c. Control panels and fire alarm devices and appliances disconnected and removed shall be turned over to the Contracting Officer.
- d. Properly dispose of fire alarm outlet and junction boxes, wiring, conduit, supports, and other such items.

#### 3.4 CONNECTION OF NEW SYSTEM

The following new system connections shall be made during the last phase of construction, at the beginning of the preliminary tests. New system connections shall include:

- a. Connection of new control modules to clean agent releasing panels.
- b. Connection of new system transmitter to existing base fire reporting system.

Once these connections are made, system shall be left energized and new

audio/visual devices deactivated. Report immediately to the Contracting Officer, coordination and field problems resulting from the connection of the above components.

### 3.5 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. Firestopping of all penetrations in Image Generator Rooms shall meet the minimum required fire resistance rating and prevent clean agent leakage.

### 3.6 PAINTING

Paint exposed electrical, fire alarm conduit, and surface metal raceway to match adjacent finishes in exposed areas. Paint junction boxes red in unfinished areas and conduits and surface metal raceways shall be painted with a 1-inch wide red band every 10 feet in unfinished areas. The inside cover of junction boxes must be identified as "FIRE ALARM". Painting shall comply with Section 09 90 00 PAINTS AND COATINGS.

### 3.7 FIELD QUALITY CONTROL

#### 3.7.1 Testing Procedures

Submit detailed test procedures, prepared and signed by a Registered Professional Engineer or a NICET Level IV Fire Alarm Technician, and signed by representative of the installing company, for the fire detection and alarm system 60 days prior to performing system tests. Detailed test procedures must not be general in nature such as "Meet NFPA 72" or "Meet Manufacturer's Recommendations." Detailed test procedures shall include all individual devices, circuits, subpanels and associated systems including interconnection with other systems such as HVAC units. Detailed test procedures shall 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, Guard's Tour equipment, and transient (surge) suppressors. Test procedures shall include sequence of testing, time estimate for each test, and sample test data forms. The test data forms shall be in a check-off format (pass/fail with space to add applicable test data; similar to the format in NFPA 72) and shall be used for the preliminary testing and the acceptance testing. The test data forms shall record the test results and shall:

- a. Identify the NFPA Class of all Initiating Device Circuits (IDC), 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 this test shall 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 testing smoke detectors using real smoke).
- 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.

### 3.7.2 Tests Stages

#### 3.7.2.1 Preliminary Testing

Conduct preliminary tests to ensure that devices and circuits are functioning properly. Tests shall meet the requirements of paragraph entitled "Minimum System Tests." After preliminary testing is complete, provide a letter certifying that the installation is complete and fully operable. The letter shall state that each initiating and indicating device was tested in place and functioned properly. The letter shall also state that panel functions were tested and operated properly. The letter shall include the names and titles of the witnesses to the preliminary tests. The Contractor and an authorized representative from each supplier of equipment shall be in attendance at the preliminary testing to make necessary adjustments.

#### 3.7.2.2 Request for Formal Inspection and Tests

When tests have been completed and corrections made, submit a signed, dated certificate with a request for formal inspection and tests to the Contracting Offices Designated Representative (COR).

#### 3.7.2.3 Final Testing

Notify the Contracting Officer in writing when the system is ready for final acceptance testing. Submit request for test at least 15 calendar days prior to the test date. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. Furnish instruments and personnel required for the tests. A final acceptance test will not be scheduled until the following are provided at the job site:

- a. The systems manufacturer's technical representative
- b. Marked-up red line drawings of the system as actually installed
- c. Megger test results
- d. Loop resistance test results
- e. Complete program printout including input/output addresses

The final tests will be witnessed by the cognizant Fire Protection Engineer and or Contracting Offices Designated Representative (COR). At this time, any and all required tests shall be repeated at their discretion.

#### 3.7.2.4 System Acceptance

Following acceptance of the system, as-built drawings and O&M manuals

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

- a. Furnish digital PDF format and one set of full-size paper as-built drawings and schematics. The drawings shall be prepared on uniform sized sheets not less than 30 by 42 inches with 8 by 4-inch title block similar to contract drawings. Furnish one set of CD or DVD discs containing software back-up and CAD based drawings in latest version of AutoCAD and DXF format 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.

### 3.7.3 Minimum System Tests

Test the system in accordance with the procedures outlined in NFPA 72, ISO 7240-16, IEC 60268-16. The required tests are as follows:

- a. Megger Tests: After wiring has been installed, and prior to making any connections to panels or devices, wiring shall be megger tested for insulation resistance, grounds, and/or shorts. Conductors with 300 volt rated insulation shall be tested at a minimum of 250 VDC. Conductors with 600 volt rated insulation shall be tested at a minimum of 500 VDC. The tests shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.
- b. 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 shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.
- c. Verify the absence of unwanted voltages between circuit conductors and ground. The tests shall be accomplished at the preliminary test with results available at the final system test.
- d. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.
- e. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke sensors shall be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors shall comply with the requirements of NFPA 72.
- 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 FACP. Hard copy records of the software shall 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 sensors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke sensors shall 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.

#### 3.7.3.1 Intelligibility Tests

Intelligibility testing of the System shall be accomplished in accordance with [NFPA 72](#) for Voice Evacuation Systems, [IEC 60268-16](#), 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 .7.
- 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 DOD installation, 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 shall 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 ISO 7240-19 and ISO 7240-16 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

### 3.8 INSTRUCTION OF GOVERNMENT EMPLOYEES

#### 3.8.1 Instructor

Include in the project the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the inspection, testing, and maintenance of the system provided. The instructor shall train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm and fire detection system. Each instructor shall be thoroughly familiar with all parts of this installation. The instructor shall be trained in operating theory as well as in practical O&M work. Submit the instructor's information and qualifications including the training history.

#### 3.8.2 Required Instruction Time

Provide 8 hours of instruction after final acceptance of the system. The instruction shall be given during regular working hours on such dates and times as are selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training shall allow for rescheduling for unforeseen maintenance and/or fire department responses.

### 3.9 Technical Data and Computer Software

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training shall familiarize designated government personnel with proper operation of the installed system. The maintenance training course shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

### 3.10 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit digital PDF format and six copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions shall be a single volume or in separate volumes and may be submitted as a Technical Data Package. Manuals shall be approved prior to



training. The Interior Fire Alarm and Mass Notification System Operation and Maintenance Instructions shall include:

- a. "Manufacturer Data Package 5" 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 shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features.
- c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.
- d. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements.
- e. Software delivered for this project shall be provided, on each type of CD/DVD media utilized.
- f. Printouts of configuration settings for all devices.
- g. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference. All data (devices, testing frequencies, etc.) shall comply with UFC 3-601-02.

### 3.11 EXTRA MATERIALS

#### 3.11.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system shall be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During guarantee period, the service technician shall be on-site within 24 hours after notification. All repairs shall be completed within 24 hours of arrival on-site.

#### 3.11.2 Interchangeable Parts

Spare parts furnished shall be directly interchangeable with the corresponding components of the installed system. Spare parts shall be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts shall be delivered to the Contracting Officer at the time of the final acceptance testing.

#### 3.11.3 Spare Parts

Furnish the following spare parts and accessories:

- a. Four fuses for each fused circuit.
- b. Two of each type of notification appliance in the system (e.g. speaker, FA strobe, MNS strobe, etc.)

- c. Two of each type of initiating device included in the system (e.g. smoke detector, thermal detector, manual station, etc.)

#### 3.11.4 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment shall be furnished to the Contracting Officer.

-- 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

AASHTO T 224 (2010) Standard Method of Test for  
Correction for Coarse Particles in the  
Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600 (2017) Installation of Ductile-Iron Mains  
and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2015; Errata 1 2015; Errata 2 2016)  
Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M (2018) Standard Specification for Concrete  
Aggregates

ASTM C136/C136M (2014) Standard Test Method for Sieve  
Analysis of Fine and Coarse Aggregates

ASTM D698 (2012; E 2014; E 2015) Laboratory  
Compaction Characteristics of Soil Using  
Standard Effort (12,400 ft-lbf/cu. ft.  
(600 kN-m/cu. m.))

ASTM D1140 (2017) Standard Test Methods for  
Determining the Amount of Material Finer  
than 75- $\mu$ m (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/ft <sup>3</sup> ) (2700 kN-m/m <sup>3</sup> )
ASTM D1883	(2016) Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2017) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2937	(2017; E 2017; E 2018) Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

## 1.2 DEFINITIONS

### 1.2.1 Satisfactory Materials

Satisfactory materials 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, ML, MH. Satisfactory materials for grading comprise stones less than [8 inches](#), except for fill material for pavements and supported structures which comprise stones less than [3 inches](#) in any dimension.

### 1.2.2 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; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

### 1.2.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in [ASTM D2487](#) as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. 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 C136/C136M and ASTM D1140.

#### 1.2.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum 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 maximum dry density in accordance with AASHTO T 180 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

#### 1.2.5 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 6 inch 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.

#### 1.2.6 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.

#### 1.2.7 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

#### 1.2.8 Select Granular Material

##### 1.2.8.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, or SP by ASTM D2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140. Provide a minimum coefficient of permeability of 0.002 feet per minute when tested in accordance with ASTM D2434.

##### 1.2.8.2 California Bearing Ratio Values

Bearing Ratio: At 0.1 inch penetration, provide a bearing ratio of 14 percent at 95 percent ASTM D1557 maximum dry density as determined in

accordance with [ASTM D1883](#) for a laboratory soaking period of not less than 4 days. Provide 1 percent maximum expansion. Conform the combined material to the following sieve analysis:

Sieve Size	Percent Passing by Weight
2-1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

#### 1.2.9 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 3 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free the initial backfill material of stones larger than 3 inches in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

#### 1.2.10 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 15 when tested in accordance with [ASTM D4318](#).

#### 1.2.11 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material are a uniformly graded washed sand with a maximum particle size of 3 inch and less than 5 percent passing the No. 200 size sieve, and with not more than 3 percent by weight finer than 0.02 mm grain size.

### 1.3 SYSTEM DESCRIPTION

Subsurface soil boring logs are shown on the drawings. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

#### 1.3.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation. Finish the specified excavation on a classified basis, in accordance with the following designations and classifications.

##### 1.3.1.1 Common Excavation

Include common excavation with the satisfactory removal and disposal of all materials not classified as rock excavation.

### 1.3.2 Blasting

Blasting will not be permitted.

### 1.4 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-01 Preconstruction Submittals

Shoring; G

#### SD-03 Product Data

Utilization of Excavated Materials; G

Opening of any Excavation

#### SD-07 Certificates

Testing

## PART 2 PRODUCTS

### 2.1 BURIED WARNING AND IDENTIFICATION TAPE

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

Warning Tape Color Codes	
Gray	Compressed Air

#### 2.1.1 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.

#### 2.1.2 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.

### 2.2 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

### 2.3 MATERIAL FOR RIP-RAP

Provide bedding material, filter fabric, and rock conforming to NM-DOT SSS State Standard for construction indicated.

#### 2.3.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well 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 six.

#### 2.3.2 Rock

Provide rock fragments sufficiently durable to 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 so 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.

### 2.4 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel 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. 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.

### PART 3 EXECUTION

#### 3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 4 inches. Spread topsoil on areas already graded and prepared for topsoil or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. 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.

#### 3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from other approved areas selected by the Contractor as specified.

##### 3.2.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on Drawings. Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 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.

##### 3.2.2 Drainage Structures

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. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level

until just before the concrete or masonry is to be placed.

### 3.2.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. 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 or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

### 3.2.4 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. Do not permit French drains, sumps, ditches or trenches 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. Take 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 1 foot below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in previous zones below subgrade elevation in layered soils to prevent uplift.

### 3.2.5 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 in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 5 feet high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in. Shore vertical trench walls more than 5 feet high. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches 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 sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

#### 3.2.5.1 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 3 **inch** or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

#### 3.2.5.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, remove such material 4 **inch** below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

#### 3.2.5.3 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 select granular material as provided in paragraph BACKFILLING 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.

#### 3.2.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 **inches** clear between the outer structure surfaces and the face of the excavation or support members or 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 loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

#### 3.2.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Excavation made with power-driven equipment is not permitted within 2 **feet** of known Government-owned 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.

### 3.2.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact over excavations and changes in grade due to pile driving operations to 95 percent of ASTM D698 maximum dry density.

### 3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from the borrow areas from approved private sources. 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. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

### 3.4 OPENING AND DRAINAGE OF EXCAVATION

Notify the Contracting Officer sufficiently in advance of the opening of any excavation to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Ensure that excavation of any area or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

### 3.5 SHORING

#### 3.5.1 General Requirements

Submit a Shoring and Sheet piling plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheet piling of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheet piling as excavations are backfilled, in a manner to prevent caving.

#### 3.5.2 Geotechnical Engineer

Hire a Professional Geotechnical Engineer licensed in the State of New Mexico to provide inspection of 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 updating the excavation, sheet piling and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contracting Officer is responsible for

arranging meetings with the Geotechnical Engineer at any time throughout the contract duration.

### 3.6 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Do not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Place and grade stockpiles of satisfactory 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. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

### 3.7 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. For pile foundations, stop the excavation at an elevation of from **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. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

### 3.8 GROUND SURFACE PREPARATION

#### 3.8.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of **6 inches** before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of **6 inches**, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of **12 inches** and compact it as specified for the adjacent fill.

#### 3.8.2 Frozen Material

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 provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

### 3.9 UTILIZATION OF EXCAVATED MATERIALS

Dispose unsatisfactory materials removing from excavations into designated

waste disposal or spoil areas. Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Submit procedure and location for disposal of unused satisfactory material. [Submit proposed source of borrow material](#). Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to 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.

### 3.10 BURIED TAPE AND DETECTION WIRE

#### 3.10.1 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.

#### 3.10.2 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.

### 3.11 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, in successive horizontal layers of loose material not more than [8 inches](#) in depth. Compact to at least 90 percent laboratory maximum dry density for cohesive materials or 95 percent laboratory maximum dry density for cohesionless materials, to prevent wedging action or eccentric loading upon or against the structure. Backfill material must be within the range of -2 to +2 percent of optimum moisture content at the time of 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 GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

#### 3.11.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to [3 feet](#) above the top of pipe prior to performing the required pressure tests. Leave the joints and couplings uncovered during the pressure test.

#### 3.11.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

#### 3.11.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

#### 3.11.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. 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 as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum dry density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

##### 3.11.1.3.1 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.

##### 3.11.1.3.2 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.

##### 3.11.1.3.3 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill as indicated.

##### 3.11.1.3.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as having a classification of GW or GP in accordance with ASTM D2487 for bedding and backfill as indicated. Do not exceed maximum particle size of 3 inches.

#### 3.11.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, supported structures, and airfields, with satisfactory material. Place backfill material and compact as follows:

##### 3.11.1.4.1 Roadways

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

#### 3.11.1.4.2 Sidewalks, 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 dry density for cohesive soils and 90 percent maximum dry density for cohesionless soils. Allow water flooding or jetting methods of compaction for granular noncohesive backfill material. Do not allow water jetting to penetrate the initial backfill. Apply this requirement to all other areas not specifically designated above.

#### 3.11.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 5 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.

### 3.12 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

#### 3.12.1 Gas Distribution

Excavate trenches to a depth that will provide a minimum 18 inches of cover in rock excavation and a minimum 24 inch of cover in other excavation.

#### 3.12.2 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.

#### 3.12.3 Heat Distribution System

Free initial backfill material of stones larger than 1/4 inch in any dimension.

#### 3.12.4 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.

#### 3.12.5 Pipeline Casing

Provide new smooth wall steel pipeline casing under new existing pavement in a trench. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated.

##### 3.12.5.1 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other



fluids in connection with the boring operation.

#### 3.12.5.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

#### 3.12.5.3 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight end seals as indicated.

#### 3.12.6 Rip-Rap Construction

Construct rip-rap on bedding material in accordance with NM DOT State Standard, paragraph 602 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.

##### 3.12.6.1 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.

##### 3.12.6.2 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.

#### 3.13 SUBGRADE PREPARATION

##### 3.13.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a dump truck loaded with 4 cubic yards of soil or 15 ton, pneumatic-tired roller. Operate the roller or truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Contracting Officer. Undercut rutting or pumping of material as directed by the Contracting Officer and replace with fill and backfill select material.

##### 3.13.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating

required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

### 3.13.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas and supported structures, compact each layer of the embankment to at least 95 percent of laboratory maximum dry density.

#### 3.13.3.1 Subgrade for Pavements

Compact subgrade for pavements to at least 95 percentage laboratory maximum dry density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 12 inch of subgrade.

### 3.14 FINISHING

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 that the degree of finish 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 from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

#### 3.14.1 Subgrade and Embankments

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 the 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, or frozen subgrade.

#### 3.14.2 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.

### 3.14.3 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.

### 3.15 PLACING TOPSOIL

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 4 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas.

### 3.16 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

- a. Determine field in-place density in accordance with ASTM D1556/D1556M, ASTM D2167 or ASTM D6938. When ASTM D6938 is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556/D1556M. ASTM D6938 results in a wet unit weight of soil in determining the moisture content of the soil when using this method.
- b. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer. ASTM D2937, use the Drive Cylinder Method only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.
- c. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

#### 3.16.1 Fill and Backfill Material Gradation

One test per 500 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C136/C136M or ASTM D1140.

### 3.16.2 In-Place Densities

- a. One test per 10,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.
- b. One test per 10,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.
- c. One test per 100 linear feet, or fraction thereof, of each lift of embankment or backfill for roads.

### 3.16.3 Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities by ASTM D1556/D1556M as follows:

- a. One check test per lift for each 10,000 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.
- b. One check test per lift for each 10,000 square feet, of fill or backfill areas compacted by hand-operated machines.
- c. One check test per lift for each 100 linear feet, or fraction thereof, of embankment or backfill for roads.

### 3.16.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer.

### 3.16.5 Optimum Moisture and Laboratory Maximum Dry Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum dry density values. One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum dry density.

### 3.16.6 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

### 3.16.7 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to the finished grade surface, inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the Contracting Officer. Inspect pipe sizes larger than 36 inches, while inspecting smaller diameter pipe by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. 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.

3.17 DISPOSITION OF SURPLUS MATERIAL

Remove surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber to a Government disposal area.

-- End of Section --

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## SECTION 31 05 19

### GEOTEXTILE

#### 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 D4354	(2012) 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	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011; R 2018) Standard Practice for Determining the Specification Conformance of Geosynthetics
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

##### 1.2 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Thread

Manufacturing Quality Control Sampling and Testing

SD-04 Samples

Quality Assurance Samples and Tests

SD-07 Certificates

Geotextile

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle geotextile in accordance with [ASTM D4873/D4873M](#).

1.3.1 Delivery

Notify the Contracting Officer a minimum of 24 hours prior to delivery and unloading of geotextile rolls packaged in an opaque, waterproof, protective plastic wrapping. The plastic wrapping shall not be removed until deployment. If quality assurance samples are collected, immediately rewrap rolls with the plastic wrapping. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

1.3.2 Storage

Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of [160 degrees F](#), or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

1.3.3 Handling

Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

PART 2 PRODUCTS

2.1 RAW MATERIALS

A minimum of 7 days prior to scheduled use, submit manufacturer's certificate of compliance stating that the geotextile meets the requirements of this section. For needle punched geotextiles, the manufacturer shall also certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers. The certificate of compliance shall be attested to by a person having legal authority to bind the geotextile manufacturer.



### 2.1.1 Geotextile

Provide geotextile that is a woven or nonwoven pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. Regrind material, which consists of edge trimmings and other scraps that have never reached the consumer, may be used to produce the geotextile. Post-consumer recycled material shall not be used. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Geotextiles shall meet the requirements specified in Table 1. Where applicable, Table 1 property values represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll values.

TABLE 1 MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE			
PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	LBS	160	ASTM D4632/D4632M
SEAM STRENGTH	LBS	300	ASTM D4632/D4632M
PUNCTURE	LBS	55	ASTM D6241
TRAPEZOID TEAR	LBS	55	ASTM D4533/D4533M
APPARENT OPENING SIZE	U.S. SIEVE	#50	ASTM D4751
PERMITTIVITY	SEC -1	0.10	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	PERCENT	50 AT 500 HRS	ASTM D4355/D4355M

### 2.1.2 Thread

A minimum of 7 days prior to scheduled use, submit proposed thread type for sewn seams along with data sheets showing the physical properties of the thread. Construct sewn seams with high-strength polyester, nylon, or other approved thread type. Thread shall have ultraviolet light stability equivalent to the geotextile and the color shall contrast with the geotextile.

## 2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

The Manufacturer is responsible for establishing and maintaining a quality

control program to assure compliance with the requirements of the specification. A minimum of 7 days prior to scheduled use, submit manufacturer's quality control manual. Documentation describing the quality control program shall be made available upon request. Perform manufacturing quality control sampling and testing in accordance with the manufacturer's approved quality control manual. As a minimum, geotextiles shall be randomly sampled for testing in accordance with [ASTM D4354](#), Procedure A. Acceptance of geotextile shall be in accordance with [ASTM D4759](#). Tests not meeting the specified requirements will result in the rejection of applicable rolls.

### PART 3 EXECUTION

#### 3.1 [QUALITY ASSURANCE SAMPLES AND TESTS](#)

##### 3.1.1 Quality Assurance Samples

Provide assistance to the Contracting Officer in the collection of quality assurance samples for quality assurance testing; assign 7 days in the schedule to allow for testing. Collect samples upon delivery to the site at the request of the Contracting Officer in accordance with [ASTM D4354](#), Procedure B. Lot size for quality assurance sampling shall be considered to be the shipment quantity of the product or a truckload of the product, whichever is smaller. The unit size shall be considered one roll of geotextile. Identify samples with a waterproof marker by manufacturer's name, product identification, lot number, roll number, and machine direction. The date and a unique sample number shall also be noted on the sample. Discard the outer layer of the geotextile roll prior to sampling a roll. Samples shall then be collected by cutting the full-width of the geotextile sheet a minimum of [3 feet](#) long in the machine direction. Rolls which are sampled shall be immediately resealed in their protective covering.

##### 3.1.2 Quality Assurance Tests

Provide quality assurance samples to an Independent Laboratory. Samples will be tested to verify that geotextile meets the requirements specified in Table 1. Test method [ASTM D4355/D4355M](#) shall not be performed on the collected samples. Geotextile product acceptance shall be based on [ASTM D4759](#). Tests not meeting the specified requirements will result in the rejection of applicable rolls.

#### 3.2 INSTALLATION

##### 3.2.1 Subgrade Preparation

The surface underlying the geotextile shall be smooth and free of ruts or protrusions which could damage the geotextile. Subgrade materials and compaction requirements shall be in accordance with Section [31 00 00](#) EARTHWORK.

##### 3.2.2 Placement

Notify the Contracting Officer a minimum of 24 hours prior to installation of geotextile. Geotextile rolls which are damaged or contain imperfections shall be repaired or replaced as directed. The geotextile shall be laid flat and smooth so that it is in direct contact with the subgrade. The geotextile shall also be free of tensile stresses, folds, and wrinkles. On slopes steeper than 10 horizontal on 1 vertical, lay the

geotextile with the machine direction of the fabric parallel to the slope direction.

### 3.3 SEAMS

#### 3.3.1 Overlap Seams

Continuously overlap geotextile panels a minimum of 12 inches at all longitudinal and transverse joints. Where seams must be oriented across the slope, lap the upper panel over the lower panel. If approved, sewn seams may be used instead of overlapped seams.

#### 3.3.2 Sewn Seams

Factory and field seams shall be continuously sewn on all slopes steeper than 1 vertical on 4 horizontal. The stitch type used shall be a 401 locking chain stitch or as recommended by the manufacturer. Provide Quality Assurance seam samples to the Government at the request of the Contracting Officer. Seam strength shall meet the minimum requirements specified in Table 1. The thread at the end of each seam run shall be tied off to prevent unraveling. Skipped stitches or discontinuities shall be sewn with an extra line of stitching with a minimum of 18 inches of overlap.

### 3.4 PROTECTION

Protect the geotextile during installation from clogging, tears, and other damage. Damaged geotextile shall be repaired or replaced as directed. Use adequate ballast (e.g. sand bags) to prevent uplift by wind. The geotextile shall not be left uncovered for more than 14 days after installation.

### 3.5 REPAIRS

Repair torn or damaged geotextile. Clogged areas of geotextile shall be removed. Perform repairs by placing a patch of the same type of geotextile over the damaged area. The patch shall extend a minimum of 12 inches beyond the edge of the damaged area. Patches shall be continuously fastened using approved methods. The machine direction of the patch shall be aligned with the machine direction of the geotextile being repaired. Remove and replace geotextile rolls which cannot be repaired. Repairs shall be performed at no additional cost to the Government.

### 3.6 PENETRATIONS

Construct engineered penetrations of the geotextile by methods recommended by the geotextile manufacturer.

### 3.7 COVERING

Do not cover geotextile prior to inspection and approval by the Contracting Officer. Place cover soil in a manner that prevents soil from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves. On side slopes, soil backfill shall be placed from the bottom of the slope upward. Cover soil shall not be dropped onto the geotextile from a height greater than 3 feet. No equipment shall be operated directly on top of the geotextile without approval of the Contracting Officer. Use equipment with ground pressures less than 7 psi to place the

first lift over the geotextile. A minimum of 12 inches of soil shall be maintained between full-scale construction equipment and the geotextile. Cover soil material type, compaction, and testing requirements are described in Section 31 00 00 EARTHWORK. Equipment placing cover soil shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 5 mph.

-- End of Section --

SECTION 31 11 00

CLEARING AND GRUBBING

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

(2008; Change 1-2017; Change 2-2018) DOD  
Pest Management Program

1.2 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Herbicide Application Plan

SD-03 Product Data

Tree Wound Paint

Herbicides; G

SD-07 Certificates

Qualifications; G

SD-11 Closeout Submittals

Pest Management Report

1.3 QUALITY CONTROL

1.3.1 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. These forms may be obtained from the main web site:  
<http://www.dtic.mil/whs/directives/forms/eforms/dd1532-1.pdf>

### 1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Submit a copy of the pesticide applicator certificates.

## 1.4 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.

### 1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

### 1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permitted unless it is written into the contract.

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

#### 2.1.2 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

## PART 3 EXECUTION

### 3.1 PREPARATION

#### 3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

### 3.1.2 Protection

#### 3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

#### 3.1.2.2 Trees, Shrubs, and Existing Facilities

Provide protection in accordance with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. 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.

#### 3.1.2.3 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 Application

#### 3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

##### 3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

##### 3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

### 3.3 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.

### 3.3.1 Tree Removal

Where indicated or directed, trees and stumps that are designated as trees shall be removed 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.

### 3.3.2 Pruning

Prune or 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.

### 3.3.3 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.

## 3.4 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 similar materials shall become the property of the Contractor and disposed 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 similar materials shall become the property of the Contractor and disposed as specified.

## 3.5 CLOSEOUT ACTIVITIES

### 3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and manufacturer of herbicide, formulation, concentration or rate of



Combat Rescue Helicopter (CRH) Simulator Facility ADAL  
Kirtland Air Force Base, New Mexico

W912PP23R0009

application used.

-- End of Section --

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SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID 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.

ASTM INTERNATIONAL (ASTM)

ASTM C1016	(2014) Standard Test Method for Determination of Water Absorption of Sealant Backing (Joint Filler) Material
ASTM D789	(2015) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)
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
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U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement
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1.2 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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's Recommendations; G

Equipment

SD-04 Samples

Materials; G

SD-06 Test Reports

Certified Copies of the Test Reports; G

1.3 QUALITY ASSURANCE

1.3.1 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable 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. Samples will be retained by the Government for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based 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 14 days prior to the beginning of work. No material will be allowed to be used until it has been approved.

1.3.2 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least **200 feet** long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all 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. 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. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the contract unit price per linear foot for sealing items scheduled. Prepare and seal all other joints in the manner approved for sealing the test section.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.5 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of **50 degrees F** and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the joint.

## PART 2 PRODUCTS

### 2.1 SEALANTS

Materials for sealing cracks in the various paved areas indicated on the drawings shall be as follows:

Area	Sealing Material
Concrete Drives	ASTM D6690, Type II and COE CRD-C 525
Concrete Drives	ASTM D6690, Type III and COE CRD-C 525

### 2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

### 2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have 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. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C1016. Use backup material that is 25 plus or minus 5 percent larger in diameter than the nominal width of the crack.

### 2.4 BOND BREAKING TAPES

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have 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. The bond breaker tape shall be approximately 1/8 inch wider than the nominal width of the joint and shall not bond to the joint sealant.

## PART 3 EXECUTION

### 3.1 EXECUTING EQUIPMENT

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 30 days prior to use on the project.

#### 3.1.1 Joint Cleaning Equipment

##### 3.1.1.1 Tractor-Mounted Routing Tool

Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The

use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used 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 or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean 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. The maximum nozzle opening should not exceed  $1/4$  inch. The air compressor shall be portable and capable of furnishing 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. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary 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. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

#### 3.1.1.5 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

### 3.1.2 Sealing Equipment

#### 3.1.2.1 Hot-Poured Sealing Equipment

Unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; 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 type thermometer for indicating the temperature of the sealant. Applicator unit shall be designed so the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

#### 3.1.2.2 Two-Component, Cold-Applied, Machine Mix Sealing Equipment

Provide equipment used for proportioning, mixing, and installing **FS SS-S-200** Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of 1 to 1 by volume using pumps with an accuracy of plus or minus 5 percent for the quantity of each component. Reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed **90 degrees F**. Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of **10 to 60 gallons** per hour and through a range of application pressures from **50 to 1500 psi** as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will 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.

#### 3.1.2.3 Two-Component, Cold-Applied, Hand-Mix Sealing Equipment

Mixing equipment for **FS SS-S-200** Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the **manufacturer's recommendations**. Submit printed copies of manufacturer's recommendations, 14 days prior to use on the project, where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

#### 3.1.2.4 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing **ASTM D5893/D5893M** single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will 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. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

### 3.2 SAFETY

Do not place joint sealant within **25 feet** of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Thoroughly clean joints in this area and leave them unsealed.

### 3.3 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

#### 3.3.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings, using the tractor-mounted routing equipment, concrete saw, or waterblaster as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks. Chipping, spalling, or otherwise damaging the concrete will not be allowed.

#### 3.3.2 Sawing

##### 3.3.2.1 Refacing of Joints

Accomplish refacing and facing of joints using a concrete saw as specified in paragraph EQUIPMENT to remove all residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings and to saw through sawed and filler-type joints to loosen and remove material until the joint is clean and open to the full specified width and depth. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

##### 3.3.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in paragraph EQUIPMENT. The saw blade shall be 6 inches or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade, as necessary, with suitable dummy (or used) blades or washers. Immediately following the sawing operation, thoroughly clean the crack opening using a water jet to remove all saw cuttings and debris.

#### 3.3.3 Sandblasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 1/2 inch from the joint edges shall be waterblasted clean. use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water.

#### 3.3.4 Back-Up Material

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 back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed



at the specified depth and is not stretched or twisted during installation.

### 3.3.5 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or depth of the joint opening does not allow for 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. Securely bond the tape to bottom of the joint opening so it will not float up into the new sealant.

### 3.3.6 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

## 3.4 PREPARATION OF SEALANT

### 3.4.1 Hot-Poured Sealants

Do not heat sealants conforming to [ASTM D6690](#) in excess of the safe heating temperature recommended by the manufacturer as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

### 3.4.2 Type M Sealants

Inspect the [FS SS-S-200](#) Type M sealant components and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection. Prior to transfer of the components from the shipping containers to the appropriate reservoir of the application equipment, thoroughly mix the materials to ensure homogeneity of the components and incorporation of all constituents at the time of transfer. When necessary for remixing prior to transfer to the application equipment reservoirs, warm the components to a temperature not to exceed [90 degrees F](#) by placing the components in heated storage or by other approved methods but in no case shall the components be heated by direct flame, or in a single walled kettle, or a kettle without an oil bath.

### 3.4.3 Type H Sealants

Mix the [FS SS-S-200](#) Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

### 3.4.4 Single-Component, Cold-Applied Sealants

Inspect the [ASTM D5893/D5893M](#) sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be

cause for rejection.

### 3.5 INSTALLATION OF SEALANT

#### 3.5.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open joints, that cannot be sealed under the conditions specified, or when rain interrupts sealing operations shall be recleaned and allowed to dry prior to installing the sealant.

#### 3.5.2 Sealing Joints

Immediately preceding, but not more than 50 feet ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch plus or minus 1/16 inch below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

### 3.6 INSPECTION

#### 3.6.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

#### 3.6.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.

#### 3.6.3 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. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein at no additional cost to the Government.

### 3.7 CLEAN-UP

Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

Combat Rescue Helicopter (CRH) Simulator Facility ADAL  
Kirtland Air Force Base, New Mexico

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## 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.

##### 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
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##### 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, nematocides, molluscicides and rodenticides.

###### 1.2.2 Stand of Turf

95 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 93 00 EXTERIOR PLANTS applies to this section for installation of trees, shrubs, vines, and wildflower, with additions and modifications herein.

##### 1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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

Integrated Pest Management Plan; G

SD-03 Product Data

Fertilizer; G

SD-07 Certificates

Maintenance Inspection Report

Plant Quantities; G

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 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, weeding, pruning, stake and guy adjusting, for all newly installed landscape areas and existing plant material, 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. Policing must extend to both sides of fencing or walls. 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 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.

#### 3.2.1 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.

#### 3.2.2 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.

#### 3.2.3 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.

##### 3.2.3.1 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.

#### 3.2.3.2 Tree Maintenance

Tree maintenance must include adjustment of stakes, ties, guy supports and turnbuckles, watering, fertilizing, pest control, mulching, pruning for health and safety and fall leaf cleanup. Inspect and adjust stakes, ties, guy supports and turnbuckles 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.

#### 3.2.4 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, guys, 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.

#### 3.2.5 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.

#### 3.2.6 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:

##### 3.2.6.1 Total Plants on Site

Plants have been accepted and required number of replacements have been installed.

##### 3.2.6.2 Mulching and Weeding

Planter beds and earth mound water basins are properly mulched and free of weeds.



#### 3.2.6.3 Tree Supports

Stakes guys guys and turnbuckles are in good condition.

#### 3.2.6.4 Remedial Work

Remedial measures directed by the Contracting Officer to ensure plant material survival and promote healthy growth have been completed.

### 3.3 FIELD QUALITY CONTROL

#### 3.3.1 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.

#### 3.3.2 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.

#### 3.3.3 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 --

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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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS  
(AASHTO)

- |              |  |
|--------------|--|
| AASHTO T 88  | (2013) Standard Method of Test for Particle Size Analysis of Soils   |
| 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 |
| AASHTO T 224 | (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test                                   |

ASTM INTERNATIONAL (ASTM)

- |                   |   |
|-------------------|---|
| ASTM C29/C29M     | (2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate  |
| ASTM C117         | (2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing   |
| ASTM C131/C131M   | (2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine                                |
| ASTM C136/C136M   | (2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates  |
| ASTM D75/D75M     | (2014) 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 <sup>3</sup> ) (2700 kN-m/m <sup>3</sup> ) |

ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2017) 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 D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2016) 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, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

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

### SD-03 Product Data

Plant, Equipment, and Tools; G

### SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

## 1.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work will be subject to approval by the Contracting Officer 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.

## 1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

### 1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

### 1.5.2 Tests

#### 1.5.2.1 Sieve Analysis

Perform sieve analysis 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 AASHTO T 88.

#### 1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

#### 1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with paragraph DEGREE OF COMPACTION.

#### 1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, ASTM D2167, 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 paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 will be used to determine the moisture content of the soil. Also 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 paragraph Calibration, 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.

#### 1.5.2.5 Wear Test

Perform wear tests on rigid pavement base course material in conformance with ASTM C131/C131M.

#### 1.5.2.6 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M.

### 1.6 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.

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or slag, 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. The percentage of loss of material retained on the No. 4 sieve must not exceed 50 percent after 500 revolutions when tested in accordance with ASTM C131/C131M. At least 50 percent by weight retained on each sieve must have 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 slag that is an air-cooled, blast-furnace product having a dry weight of not less than 65 pcf. Provide aggregates having a maximum size of 2 inches and within the limits specified as follows:

Maximum Allowable Percentage by Weight  
Passing Square-Mesh Sieve

Sieve Designation	Rigid Pavement Base Course
No. 10	85
No. 200	15

Particles having diameters less than 0.02 mm must not be in excess of 3 percent by weight of the total sample tested as determined in accordance with AASHTO T 88. The portion of any blended component and of the completed course passing the No. 40 sieve must be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 6. The Contractor is responsible for any additional stability required to provide a working platform for construction equipment. If the Contractor can demonstrate with a test section that a material has adequate stability to support construction equipment, the fractured face requirement can be deleted, subject to the approval of the Contracting Officer.

### 2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

#### 2.2.1 Initial Tests

Perform one of each of the following 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. Sieve Analysis including 0.02 mm size material.
- b. Liquid limit and plasticity index.
- c. Moisture-density relationship.
- d. Wear.
- e. Weight per cubic foot of Slag.

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.

### 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. Clearing, stripping and excavating are the responsibility of the Contractor. 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 by the Contracting Officer 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 rigid pavement base courses 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 may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory rigid pavement base course.

### 3.7 LAYER THICKNESS

Compact the completed course to the thickness indicated. No individual layer may be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. Compact the course(s) to a total thickness that is within 1/2 inch 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. The average job thickness will be the average of all thickness measurements taken for the job and must be within 1/4 inch of the thickness indicated. Measure the total thickness of the course(s) at intervals of one measurement for each 500 square yards of completed course. Measure total thickness using 3 inch diameter test holes penetrating the completed course.

### 3.8 COMPACTION

Compact each layer of the material, as specified, with approved compaction equipment. 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. 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 base course until each layer is compacted through the full depth to at least 95 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory rigid pavement base course. Remove any materials that are found to be unsatisfactory and replace with satisfactory 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 layers, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each layer of the rigid pavement base course, as directed.

### 3.10 FINISHING

Finish the surface of the top layer of rigid pavement base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin layers of material to the top layer of rigid pavement base course to meet grade. If the elevation of the top layer of rigid pavement base course is 1/2 inch or more below grade, scarify the top layer to a depth of at least 3 inches and blend new material in and compact and proof roll to bring to grade. Make adjustments to rolling and finishing procedures as directed by the Contracting Officer to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable rigid pavement base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the unsatisfactory portion and rework and recompact it or replace as directed.

### 3.11 SMOOTHNESS TEST

Construct the top layer so that the surface shows no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Also take measurements perpendicular to the centerline at 50 foot intervals. 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 one of each of the following tests on samples taken from the placed and compacted rigid pavement base course. 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 sieve analysis including 0.02 mm size material on every lift of material placed and at a frequency of one sieve analysis for every 1,000 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 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

Do not allow traffic on the completed rigid pavement base course. Completed portions of the rigid pavement base course may be opened to limited traffic, if approved by the Contracting Officer, 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.

### 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 as directed in waste disposal areas indicated. No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 11 23

AGGREGATE BASE COURSES

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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS  
(AASHTO)

- |              |  |
|--------------|--|
| AASHTO T 88  | (2013) Standard Method of Test for Particle Size Analysis of Soils   |
| 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 |
| AASHTO T 224 | (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test                                   |

ASTM INTERNATIONAL (ASTM)

- |                 |  |
|-----------------|--|
| ASTM C29/C29M   | (2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate   |
| ASTM C117       | (2017) 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       | (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate                             |
| ASTM C131/C131M | (2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| ASTM C136/C136M | (2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates   |
| ASTM D75/D75M   | (2014) 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 <sup>3</sup> ) (2700 kN-m/m <sup>3</sup> )
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2017) 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 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 E11	(2016) 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 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, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

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

SD-03 Product Data

Plant, Equipment, and Tools; G

SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

1.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work will be subject to approval by the Contracting Officer 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.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analysis

Perform sieve analysis 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 AASHTO T 88.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with paragraph DEGREE OF COMPACTION.

#### 1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, ASTM D2167 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 paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 will be used to determine the moisture content of the soil. Also 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 paragraph Calibration 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.

#### 1.5.2.5 Wear Test

Perform wear tests on ABC course material in conformance with ASTM C131/C131M.

#### 1.5.2.6 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M on the ABC course material.

### 1.6 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.

## PART 2 PRODUCTS

### 2.1 AGGREGATES

Provide ABC consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, crushed recycled concrete, 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 consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. 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 an air dry unit weight of not less than 70 pcf as determined by ASTM C29/C29M, and meets all the requirements specified below.

#### 2.1.1.1 Aggregate Base Course

The percentage of loss of ABC coarse aggregate must not exceed 50 percent when tested in accordance with ASTM C131/C131M. Provide aggregate that contains no more than 30 percent flat and elongated particles. 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, the crushed aggregates must contain at least 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 must be at least 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 1.

#### 2.1.1.2 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.

#### 2.1.1.3 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 1 in accordance with Section 303 of the NMDOT standard specifications. Use sieves that conform to ASTM E11.

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Type 1	Type 2
1 inch	100	60-100
3/4 inch	80-100	85-95

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Type 1	Type 2
No. 4	30-60	40-70
No. 10	20-45	30-55
No. 200	3-10	6-15

NOTE 1: Particles having diameters less than 0.02 mm must not be in excess of 3 percent by weight of the total sample tested as determined in accordance with [AASHTO T 88](#).

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 by the Contracting Officer if the specific gravities vary by more than 10 percent.

## 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. The portion of any component or of the completed course passing the [No. 40](#) sieve must be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

## 2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

### 2.3.1 Initial Tests

Perform one of each of the following 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.

- Sieve Analysis including 0.02 mm material.
- Liquid limit and plasticity index.
- Moisture-density relationship.
- Wear.
- Soundness.
- Weight per cubic [foot](#) of Slag.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

### 2.3.2 Approval of Material

Tentative approval of material will be based on initial test results.



## PART 3 EXECUTION

### 3.1 GENERAL REQUIREMENTS

When the ABC is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used 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. Clearing, stripping, and excavating are the responsibility of the Contractor. 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 by the Contracting Officer 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 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 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

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain

true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification. Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. Place the layers so that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, clean the previously constructed layers of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Make adjustments in placing procedures or equipment as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

### 3.7 LAYER THICKNESS

Compact the completed base course to the thickness indicated. No individual layer may be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. Compact the base course(s) to a total thickness that is within 1/2 inch 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 recompact 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. The average job thickness will be the average of all thickness measurements taken for the job and must be within 1/4 inch of the thickness indicated. Measure the total thickness of the base course at intervals of one measurement for each 500 square yards of base course. Measure total thickness using 3 inch diameter test holes penetrating the base course.

### 3.8 COMPACTION

Compact each layer of the base course, as specified, with approved compaction equipment. 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 in this Section. 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 layer is compacted through the full depth to at least 100 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Remove any materials found to be unsatisfactory and replace with satisfactory material or rework, as directed, to meet the requirements of this specification.

### 3.9 PROOF ROLLING

In addition to the compaction specified, proof roll areas designated on the drawings by application of six coverages of a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the

areas designated, apply proof rolling to the top of the underlying material on which the base course is laid and to the top of each layer of the completed base course. Maintain water content of the underlying material and each layer of the base course as specified in Paragraph COMPACTION from start of compaction to completion of proof rolling of that layer. Remove any base course materials or any underlying materials that produce unsatisfactory results by proof rolling and replace with satisfactory materials. Then recompact and proof roll to meet these specifications.

### 3.10 EDGES OF BASE COURSE

Place the base course(s) so that the completed section will be a minimum of 2 feet wider, on all sides, than the next layer 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 layers, simultaneously roll and compact at least a 2-foot width of this shoulder material with the rolling and compacting of each layer of the base course, as directed.

### 3.11 FINISHING

Finish the surface of the top layer of base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin layers of material to the top layer of base course to meet grade. If the elevation of the top layer of base course is 1/2 inch or more below grade, scarify the top layer to a depth of at least 3 inches and blend new material in and compact and proof roll to bring to grade. Make adjustments to rolling and finishing procedures as directed by the Contracting Officer to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the unsatisfactory portion and rework and recompact it or replace as directed.

### 3.12 SMOOTHNESS TEST

Construct the top layer so that the surface shows no deviations in excess of 3/8 inch when tested with a 12-foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Also take measurements perpendicular to the centerline at 50-foot intervals. 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.

### 3.13 FIELD QUALITY CONTROL

#### 3.13.1 In-Place Tests

Perform each of the following tests on samples taken from the placed and compacted ABC. Take samples and test at the rates indicated. Perform sampling and testing of recycled concrete aggregate at twice the specified frequency until the material uniformity is established.

- a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area.

- b. Perform sieve analysis including 0.02 mm size material on every lift of material placed and at a frequency of one sieve analysis for every 500 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 square yards of base course or part thereof. Measure the thickness using test holes, at least 3 inch in diameter through the base course.

### 3.13.2 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).

### 3.14 TRAFFIC

Do not allow traffic on the completed base course. Completed portions of the base course may 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.

### 3.15 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.

### 3.16 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land as directed in waste disposal areas indicated. 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 D946/D946M (2015) Penetration-Graded Asphalt Cement  
for Use in Pavement Construction

ASTM D977 (2017) Standard Specification for  
Emulsified Asphalt

ASTM D2026/D2026M (2015) Cutback Asphalt (Slow-Curing Type)

ASTM D2027/D2027M (2013) Cutback Asphalt (Medium-Curing Type)

ASTM D2028/D2028M (2015) Cutback Asphalt (Rapid-Curing Type)

ASTM D2397/D2397M (2017) 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

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

SD-03 Product Data

Local/Regional Materials; S

## 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 D2026/D2026M, Grade SC-70 ASTM D2027/D2027M, Grade MC-30 MC-70 MC-250 ASTM D2028/D2028M, Grade RC-70 RC-250.

##### 2.1.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 SS1h ASTM D2397/D2397M, Type CSS-1 CSS-1h. Asphalt emulsion can be diluted up to 1 part water to 1 part emulsion for prime coat use. Do not dilute asphalt emulsion for tack coat use.

#### 2.2 TACK COAT

##### 2.2.1 Asphalt Cement

Provide asphalt cement conforming to ASTM D946/D946M or ASTM D6373.

##### 2.2.2 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2028/D2028M, Grade RC-70 RC-250.

##### 2.2.3 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type RS-1 MS-1 HFMS-1 SS-1 SS1h ASTM D2397/D2397M, Type CRS-1 CSS-1 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.

### 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. The prime coat is required if it will be at least 7 days before the asphalt mixture is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying layer from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Government. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. 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 --

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SECTION 32 12 16

HOT-MIX ASPHALT (HMA) FOR ROADS

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 156 | (2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures |
| AASHTO M 320 | (2017) Standard Specification for Performance-Graded Asphalt Binder   |
| AASHTO T 304 | (2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate                                       |

ASPHALT INSTITUTE (AI)

- |          |  |
|----------|--|
| AI MS-2  | (2015) Asphalt Mix Design Methods                        |
| AI MS-22 | (2001; 2nd Ed) Construction of Hot-Mix Asphalt Pavements |
| AI SP-2  | (2001; 3rd Ed) Superpave Mix Design                      |

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     | (2017) 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     | (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate   |

ASTM C131/C131M	(2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2014) 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 D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D1461	(2017) Standard Test Method for Moisture or Volatile Distillates in Asphalt 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 D2489/D2489M	(2016) Standard Test Method for Estimating Degree of Particle Coating of Asphalt Mixtures
ASTM D2950/D2950M	(2014) Density of Bituminous Concrete in Place by Nuclear Methods
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 D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2010) 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 D5444	(2015) Mechanical Size Analysis of Extracted Aggregate

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 Gyratory Compactor
ASTM D6926	(2016) Standard Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
ASTM D6927	(2015) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2012) Method of Test for Operation of California Profilograph and Evaluation of Profiles
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U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171	(1995) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate
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1.2 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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; G, S

Quality Control; G

Material Acceptance; G

SD-04 Samples

Asphalt Cement Binder

Aggregates

SD-06 Test Reports

Aggregates; G

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G

Testing Laboratory

1.3 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived by the Contracting Officer, if requested; however, meet all other requirements, including compaction.

Table 3. 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. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections indicated. Construct each course to the depth, section, or elevation required by the drawings and roll, finish, and approve it before the placement of the next course.

2.1.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved, certified scales at the Contractor's expense. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Testing Facilities

Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

2.1.1.3 Inspection of Plant

Provide the Contracting Officer with access 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.



#### 2.1.1.4 Storage bins

Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

- a. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.
- b. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

#### 2.1.2 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

#### 2.1.3 Asphalt Pavers

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

##### 2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

##### 2.1.3.2 Automatic Grade Controls

Equip the paver with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. Provide controls capable of working in conjunction with any of the following attachments:

- a. Ski-type device of not less than 30 feet in length.
- b. Taut stringline set to grade.
- c. Short ski or shoe for joint matching.

- d. Laser control.

#### 2.1.4 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient 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.

### 2.2 AGGREGATES

Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. Submit sufficient materials to produce 200 lb of blended mixture for mix design verification. 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 all aggregate test results and samples to the Contracting Officer at least 14 days prior to start of construction.

#### 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. All individual coarse aggregate sources shall meet the following requirements:

- a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.
- b. The percentage of loss shall not be greater than 18 percent after five cycles when tested in accordance with ASTM C88 using magnesium sulfate or 12 percent when using sodium sulfate.
- c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171. Fractured faces shall be produced by crushing.
- d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20 percent percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791.
- e. Slag shall be 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 shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

#### 2.2.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles free from coatings of clay, silt, or any objectionable material and containing no clay balls.

- a. All individual fine aggregate sources shall have a sand equivalent value not less than 45 when tested in accordance with [ASTM D2419](#).
- b. The fine aggregate portion of the blended aggregate shall have an uncompacted void content not less than 45.0 percent when tested in accordance with [AASHTO T 304](#) Method A.
- c. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 25 percent by weight of total aggregate.
- d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with [ASTM C142/C142M](#)

#### 2.2.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of [ASTM D242/D242M](#).

#### 2.2.4 Aggregate Gradation

The combined aggregate gradation shall conform to gradations specified in Table 4, when tested in accordance with [ASTM C136/C136M](#) and [ASTM C117](#), and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine.

Table 4. Aggregate Gradations		
Sieve Size, <a href="#">inch</a>	Gradation 1 Percent Passing by Mass (SP-III)	Gradation 2 Percent Passing by Mass (SP-IV)
<a href="#">1</a>	100	---
<a href="#">3/4</a>	90-100	100
<a href="#">1/2</a>	90	90-100
<a href="#">3/8</a>		90
<a href="#">No. 8</a>	23-49	28-58
<a href="#">No. 200</a>	2-8	2-10

#### 2.3 [ASPHALT CEMENT BINDER](#)

Submit a [5-gallon](#) sample for mix design verification. Asphalt cement binder shall conform to [AASHTO M 320](#) Performance Grade (PG) PG 76-22+, PG 76-28+, PG 70-22+, PG 70-28+, PG 76-28R+ and PG 70-28R+. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with [ASTM D140/D140M](#) and in the presence of the Contracting

Officer. Furnish these samples to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit samples of the asphalt cement specified for approval not less than 14 days before start of the test section. Submit copies of certified test data, amount, type and description of any modifiers blended into the asphalt cement binder.

## 2.4 MIX DESIGN

- a. Develop the mix design. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF). Submit proposed JMF; do not produce hot-mix asphalt for payment until a JMF has been approved. The hot-mix asphalt shall be designed in accordance with Marshall (MS-02), Superpave (SP-2), or Hveem (MS-02) procedures and the criteria shown in Table 5. Use the hand-held hammer to compact the specimens for Marshall mix design. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by [ASTM D4867/D4867M](#) is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an approved anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. Provide an antistrip agent, if required, at no additional cost. Sufficient materials to produce **200 pound** of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.
- b. At the option of the Contractor, a currently used DOT Superpave hot mix may be used in lieu of developing a Marshall hot mix design as described herein. Design the Superpave volumetric mix in accordance with [AI SP-2](#) and [ASTM D6925](#). The nominal maximum aggregate size (NMAS) shall be **1/2 inch**. Other DOT hot mix design methods (Hveem, etc.) may be suitable, as determined by the Contracting Officer. The number of compaction gyrations,  $N_{des}$ , shall be based on a design traffic of 03. to 3 million equivalent single axle loads (EASLs).
- c. Design Superpave mixes with the number of gyrations specified in Table 5, unless the DOT option is chosen.

### 2.4.1 JMF Requirements

Submit in writing the job mix formula 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 viscosity grade, penetration grade, or performance grade.
- e. Number of blows of hand-held hammer per side of molded specimen. (NA for Superpave)
- f. Number of gyrations of Superpave gyratory compactor, (NA for Marshall mix design)

- g. Laboratory mixing temperature.
- h. Lab compaction temperature.
- i. Temperature-viscosity relationship of the asphalt cement.
- j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.
- k. Graphical plots of stability (NA for Superpave), flow (NA for Superpave), air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in [AI MS-2](#).
- l. Specific gravity and absorption of each aggregate.
- m. Percent natural sand.
- n. Percent particles with 2 or more fractured faces (in coarse aggregate).
- o. Fine aggregate angularity.
- p. Percent flat or elongated particles (in coarse aggregate).
- q. Tensile Strength Ratio (TSR).
- r. Antistrip agent (if required) and amount.
- s. List of all modifiers and amount.
- t. Correlation of hand-held hammer with mechanical hammer (NA for Superpave).
- u. Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

Table 5. Mix Design Criteria		
Test Property	50 Blows or Mix Gyrations	75 Blows or Mix Gyrations
Stability, <a href="#">pounds</a> , minimum (NA for Superpave)	<a href="#">*1000</a>	<a href="#">*1800</a>
Flow, <a href="#">0.01 inch</a> , (NA for Superpave)	8-18	8-16
Air voids, percent	3-5	3-5
Percent Voids in mineral aggregate (VMA), (minimum)		
Gradation 1	13.0	13.0
Gradation 2	14.0	14.3

Table 5. Mix Design Criteria		
Test Property	50 Blows or Mix Gyrations	75 Blows or Mix Gyrations
Gradation 3	15.0	15.0
TSR, minimum percent	75	75
* This is a minimum requirement. The average during construction shall be significantly higher than this number to ensure compliance with the specifications.		
** Calculate VMA in accordance with <a href="#">AI MS-2</a> , based on <a href="#">ASTM C127</a> and <a href="#">ASTM C128</a> bulk specific gravity for the aggregate.		

#### 2.4.2 Adjustments to Field JMF

Keep the Laboratory JMF for each mixture in effect until a new formula is approved in writing by the Contracting Officer. Should a change in sources of any materials be made, perform a new laboratory jmf design and a new JMF approved before the new material is used. The Contractor will be allowed to adjust the Laboratory JMF within the limits specified below to optimize mix volumetric properties with the approval of the Contracting Officer. Adjustments to the Laboratory JMF shall be applied to the field (plant) established JMF and limited to those values as shown. Adjustments shall be targeted to produce or nearly produce 4 percent voids total mix (VTM).

TABLE 6. Field (Plant) Established JMF Tolerances	
Sieves	Adjustments (plus or minus), percent
<a href="#">1/2 inch</a>	3
<a href="#">No. 4</a>	3
<a href="#">No. 8</a>	3
<a href="#">No. 200</a>	1
Binder Content	0.4

If adjustments are needed that exceed these limits, develop a new mix design. Tolerances given above may permit the aggregate grading to be outside the limits shown in Table 4; while not desirable, this is acceptable, except for the [No. 200](#) sieve, which shall remain within the aggregate grading of Table 4.

#### 2.5 RECYCLED HOT MIX ASPHALT

Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement to produce a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed [2 inches](#).

Design the recycled HMA mix using procedures contained in [AI MS-2](#) and [AI MS-22](#). The job mix shall meet the requirements of paragraph MIX DESIGN. The amount of RAP shall not exceed 30 percent.

#### 2.5.1 RAP Aggregates and Asphalt Cement

The blend of aggregates used in the recycled mix shall meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt in the RAP for the mixture design according to [ASTM D2172/D2172M](#) or [ASTM D6307](#) using the appropriate dust correction procedure.

#### 2.5.2 RAP Mix

The blend of new asphalt cement and the RAP asphalt binder shall meet the dynamic shear rheometer at high temperature and bending beam at low temperature requirements in paragraph ASPHALT CEMENT BINDER. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph ASPHALT CEMENT BINDER.

### PART 3 EXECUTION

#### 3.1 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than [325 degrees F](#) when added to the aggregates. Performance-Graded (PG) asphalts shall be within the temperature range indicated in table above when added to the aggregate.

#### 3.2 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed [350 degrees F](#) when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

#### 3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in 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. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but no less than 25 seconds for batch plants. Establish the wet mixing time for all plants based on the procedure for determining the percentage of coated particles described in [ASTM D2489/D2489M](#), for each individual plant and for each type of aggregate used. The wet mixing time will be set to at least achieve 95 percent of coated particles. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by [ASTM D1461](#).

#### 3.4 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, clean the underlying

course of dust and debris. Apply a prime coat and/or tack coat in accordance with the contract specifications.

### 3.5 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 250 - 500 feet long and two paver passes wide placed for two lanes, with a longitudinal cold joint. The test section shall be of the same thickness as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment and personnel used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. Place the test section as part of the project pavement, as approved by the Contracting Officer.

#### 3.5.1 Sampling and Testing for Test Section

Take one random sample at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Take four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall be within the tolerances shown in Table 7 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed. The test section shall be paid for with the first lot of paving

Table 7. Test Section Requirements for Material and Mixture Properties	
Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	15 minimum



Table 7. Test Section Requirements for Material and Mixture Properties	
Property	Specification Limit
Stability, <b>pounds</b> (Average of 3 specimens) (NA for Superpave)	<b>1000</b> minimum for 50 blows
Flow, <b>0.01 inch</b> (Average of 3 specimens) (NA for Superpave)	8 - 18 for 50 blows
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 - 92.5

### 3.5.2 Additional Test Sections

If the initial test section should prove to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures and place a second test section. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

### 3.6 TESTING LABORATORY

Submit certification of compliance and Plant Scale Calibration Certification. Use a laboratory to develop the JMF that meets the requirements of **ASTM D3666**. The Government will inspect the laboratory equipment and test procedures prior to the start of hot mix operations for conformance to **ASTM D3666**. The laboratory shall maintain the Corps certification for the duration of the project. A statement signed by the manager of the laboratory stating that it meets these requirements or clearly listing all deficiencies shall be submitted to the Contracting Officer prior to the start of construction. The statement shall contain as a minimum:

- Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.
- A listing of equipment to be used in developing the job mix.
- A copy of the laboratory's quality control system.
- Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

### 3.7 TRANSPORTING AND PLACING

#### 3.7.1 Transporting

Transport the hot-mix asphalt 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. To deliver mix to the paver, use a material transfer vehicle operated to produce continuous forward motion of the paver.

### 3.7.2 Placing

Place and compact the mix 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; it shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and conform to the grade and contour indicated. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Unless otherwise permitted, placement of the mixture shall begin 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. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot; however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 10 feet from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset 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 may be spread and luted by hand tools.

### 3.8 COMPACTION OF MIXTURE

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. 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 will not be permitted. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective shall be removed full depth, replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

### 3.9 JOINTS

The formation of joints shall be performed ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

#### 3.9.1 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, it shall be made by means of placing a

bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing material at the joint. Remove the cutback material from the project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

### 3.9.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing adjacent lanes), or otherwise defective, shall be cut back a maximum of 3 inches from the top of the course with a cutting wheel to expose a clean, sound vertical surface for the full depth of the course. All cutback material shall be removed from the project. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint. The Contractor will be allowed to use an alternate method if it can be demonstrated that density, smoothness, and texture can be met.

## 3.10 QUALITY CONTROL

### 3.10.1 General Quality Control Requirements

Develop and submit an approved Quality Control Plan. Submit aggregate and QC test results. Do not produce hot-mix asphalt for payment until the quality control plan has been approved addressing all elements which affect the quality of the pavement including, but not limited to:

- a. Mix Design
- b. Aggregate Grading
- c. Quality of Materials
- d. Stockpile Management
- e. Proportioning
- f. Mixing and Transportation
- g. Mixture Volumetrics
- h. Moisture Content of Mixtures
- i. Placing and Finishing
- j. Joints
- k. Compaction
- l. Surface Smoothness

### 3.10.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site and meeting the pertinent requirements in ASTM D3666. Laboratory facilities shall be kept clean and all equipment maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to

witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor 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, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

### 3.10.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability (NA for Superpave), flow (NA for Superpave), in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

#### 3.10.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph MATERIAL ACCEPTANCE and PERCENT PAYMENT) by one of the following methods: the extraction method in accordance with [ASTM D2172/D2172M](#), Method A or B, the ignition method in accordance with [ASTM D6307](#), or the nuclear method in accordance with [ASTM D4125/D4125M](#). Calibrate the ignition oven or the nuclear gauge for the specific mix being used. For the extraction method, determine the weight of ash, as described in [ASTM D2172/D2172M](#), as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

#### 3.10.3.2 Gradation

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with [ASTM D5444](#). When asphalt content is determined by the ignition oven or nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test aggregates in accordance with [ASTM C136/C136M](#) using actual batch weights to determine the combined aggregate gradation of the mixture.

#### 3.10.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

#### 3.10.3.4 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with [ASTM C566](#).

#### 3.10.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in

accordance with [ASTM D1461](#) or an approved alternate procedure.

#### 3.10.3.6 Laboratory Air Voids, Marshall Stability and Flow

Take mixture samples at least four times per lot compacted into specimens, using 50 blows per side with the hand-held Marshall hammer as described in [ASTM D6926](#). When the Superpave gyratory compactor is used, mixes will be compacted to 50 gyrations in accordance with [ASTM D6925](#). Hot-mix provided under the DOT Superpave option shall be compacted in accordance with the DOT requirements. After compaction, determine the laboratory air voids of each specimen. Stability and flow shall be determined for the Marshall-compacted specimens, in accordance with [ASTM D6927](#).

#### 3.10.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge may be used to monitor pavement density in accordance with [ASTM D2950/D2950M](#).

#### 3.10.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT.

#### 3.10.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

#### 3.10.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer 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.

#### 3.10.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

#### 3.10.5 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 8, as a minimum. These control charts shall be posted as directed by the Contracting Officer and kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the Contractor's test results. Target values from the JMF shall also be shown 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. 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. The Quality Control Plan shall indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	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
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.
50 Blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

Table 8. 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 Last Four Samples	
	Action Limit	Suspension Limit	Action Limit	Suspension Limit
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

### 3.11 MATERIAL ACCEPTANCE

Testing for acceptability of work will be performed by an independent laboratory hired by the Contractor. Forward test results and payment calculations daily to the Contracting Officer. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 2000 short tons or 8 hours of production, whichever is less. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness 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 grade and smoothness measurements for the entire lot cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

#### 3.11.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. 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. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

#### 3.11.2 Additional Sampling and Testing

The Contracting Officer 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 in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

#### 3.11.3 Grade

The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than 0.05 foot from the plan grade established and approved at site of work. Finished surfaces at

juncture with other pavements shall coincide 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. 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. Within 5 working days, after the completion of a particular lot incorporating the final wearing surface, test the final wearing surface of the pavement for conformance with the specified plan grade. Diamond grinding may 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.

#### 3.11.4 Surface Smoothness

Use one of the following methods to test and evaluate surface smoothness of the pavement. Perform all testing in the presence of the Contracting Officer. Keep detailed notes of the results of the testing and furnish a copy to the Government immediately after each day's testing. Use the profilograph method for all longitudinal testing, except where the runs would be less than 200 feet in length and the ends where the straightedge will be used. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer.

##### 3.11.4.1 Smoothness Requirements

###### 3.11.4.1.1 Straightedge Testing

The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and all pavements shall be within the tolerances of 1/4 inch in both the longitudinal and transverse directions, when tested with an approved 12 feet straightedge.

###### 3.11.4.1.2 Profilograph Testing

The finished surfaces of the pavements shall have no abrupt change of 1/8 inch or more, and each 0.1 mile segment of each pavement lot shall have a Profile Index not greater than 9 inches/mile when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 200 feet, that direction shall be tested by the straightedge method and shall meet requirements specified above.

##### 3.11.4.2 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 such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are ground, these areas shall be retested immediately after grinding. Test each lot of the pavement in both a longitudinal and a transverse direction on parallel lines. Set the transverse lines 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lanes less than 20 feet wide and at the third points for lanes 20 feet or wider. Also test other areas having obvious deviations. Longitudinal testing lines shall be continuous across all joints.



#### 3.11.4.2.1 Straightedge Testing

Hold the straightedge in contact with the surface and move it 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 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.

#### 3.11.4.2.2 Profilograph Testing

Perform profilograph testing using approved equipment and procedures described in [CTM 526](#). The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each [0.1 mile](#) segment of each pavement lot. Grade breaks on parking lots shall be accommodated by breaking the profile segment into shorter sections and repositioning the blanking band on each segment. The "blanking band" shall be [0.2 inches](#) wide and the "bump template" shall span [1 inch](#) with an offset of [0.3 inch](#). Compute the Profile Index for each pass of the profilograph in each [0.1 mile](#) segment. The Profile Index for each segment shall be the average of the Profile Indices for each pass in each segment. The profilograph shall be operated by a DOT approved operator. Furnish a copy of the reduced tapes to the Government at the end of each day's testing.

-- End of Section --

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SECTION 32 13 13.06

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES

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 CONCRETE INSTITUTE (ACI)

ACI 301	(2016) Specifications for Structural Concrete
ACI 305.1	(2014) Specification for Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 325.12R	(2002; R 2013) Guide for Design of Jointed Concrete Pavements for Streets and Local Roads
ACI 330R	(2008) Guide for the Design and Construction of Concrete Parking Lots

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C215	(2016) Extruded Polyolefin Coatings for Steel Water Pipe
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ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2017) Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615/A615M	(2016) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2017) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A966/A966M	(2015) Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current
ASTM C31/C31M	(2019) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates

ASTM C78/C78M	(2018) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C94/C94M	(2018) Standard Specification for Ready-Mixed Concrete
ASTM C143/C143M	(2015) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2018) Standard Specification for Portland Cement
ASTM C171	(2016) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231/C231M	(2017a) 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 C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C42/C42M	(2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C494/C494M	(2017) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1542/C1542M	(2019) Standard Test Method for Measuring Length of Concrete Cores
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations

of Cementitious Materials and Aggregate  
(Accelerated Mortar-Bar Method)

ASTM C1602/C1602M

(2018) Standard Specification for Mixing  
Water Used in Production of Hydraulic  
Cement Concrete

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-250-01

(2016) Pavement Design for Roads and  
Parking Areas

## 1.2 DESIGN

This materials and construction specification is intended to be used on projects where the design was completed using UFC 3-250-01 Pavement Design for Roads, Streets, Walks, and Open Storage Areas, ACI 330R, Guide for the Design and Construction of Concrete Parking Lots or ACI 325.12R, Guide for Design of Jointed Concrete Pavements for Streets and Local Roads, or equivalent.

## 1.3 RELATED SECTIONS

Portland cement concrete pavement must use Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASES FOR FLEXIBLE PAVING, in addition to this section.

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

### SD-03 Product Data

Curing Materials; G

Admixtures; G

Dowel; G

Reinforcement; G

Submit a complete list of materials including type, brand and applicable reference specifications.

Cementitious Materials; G

Aggregate; G

### SD-04 Samples

Field-Constructed Mockup

### SD-05 Design Data

Concrete Mix Design; G

Thirty days minimum prior to concrete placement, submit a mix design, with applicable tests, for each strength and type of concrete for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required. Submittal must clearly indicate where each mix design will be used when more than one mix design is submitted. Obtain acknowledgement of approvals prior to concrete placement. Submit a new mix design for each material source change.

#### SD-06 Test Reports

Aggregate Tests; G

Concrete Slump Tests; G

Air Content Tests; G

Flexural Strength Tests; G

Cementitious Materials; G

#### SD-07 Certificates

Ready-mixed Concrete Plant; G

Batch Tickets; G

Cementitious Materials; G

### 1.5 DELIVERY, STORAGE, AND HANDLING

ASTM C94/C94M.

### 1.6 QUALITY ASSURANCE

#### 1.6.1 Ready-mixed Concrete Plant Certification

Unless otherwise approved by the Contracting Officer, ready mixed concrete must be produced and provided by a National Ready-Mix Concrete Association (NRMCA) certified plant. If a volumetric mobile mixer is used to produce the concrete, rather than ready-mixed concrete, the mixer(s) must conform to the standards of the Volumetric Mixer Manufacturers Bureau (VMMB). Verification must be made by a current VMMB conformance plate affixed to the volumetric mixer equipment.

#### 1.6.2 Contractor Qualifications

Unless waived by the Contracting Officer, the Contractor must meet one of the following criteria:

- a. Contractor must have at least one National Ready Mixed Concrete Association (NRMCA) certified concrete craftsman and at least one American Concrete Institute (ACI) Flatwork Finisher Certified craftsman on site, overseeing each placement crew during all concrete placement.

- b. Contractor must have no less than three NRMCA certified concrete installers and at least two American Concrete Institute (ACI) Flatwork Finisher Certified installers, who must be on site working as members of each placement crew during all concrete placement.

#### 1.6.3 Required Information

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports must include mill test and all other test for cementitious materials, aggregates, and admixtures. Provide maximum nominal aggregate size, combined aggregate gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Submit test reports along with the concrete mix design. Sampling and testing of materials, concrete mix design, sampling and testing in the field must be performed by a commercial testing laboratory which conforms to [ASTM C1077](#). The laboratory must be approved in writing by the Contracting Officer.

#### 1.6.4 Batch Tickets

[ASTM C94/C94M](#). Submit mandatory batch ticket information for each load of ready-mixed concrete.

#### 1.6.5 Field-Constructed Mockup

Install a minimum [400 square feet](#) to demonstrate typical joints, surface finish, texture, color, thickness, and standard of workmanship. Test panels must be placed using the mixture proportions, materials, and equipment as proposed for the project. Test mock up panels in accordance with requirements in FIELD QUALITY CONTROL.

When a test panel does not meet one or more of the requirements, the test panel must be rejected, removed, and replaced at the Contractor's expense. If the test panels are acceptable, they may be incorporated into the project with the approval of the Contracting Officer.

## PART 2 PRODUCTS

### 2.1 MATERIALS

Provide materials in accordance with Section 509 of the NMDOT Standard Specifications.

#### 2.1.1 Cementitious Materials

Cementitious materials in concrete mix must be 20 to 50 percent non-portland cement pozzolanic materials or slag by weight. Provide test data demonstrating compatibility and performance of concrete satisfactory to Contracting Officer.

##### 2.1.1.1 Cement

[ASTM C150/C150M](#), Type II or III, for high early concrete or V low alkali in accordance with Section 509 of the NMDOT Standard Specifications.

#### 2.1.1.2 Fly Ash and Pozzolan

ASTM C618, Type F, or N. Fly ash certificates must include test results in accordance with ASTM C618.

#### 2.1.1.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) must conform to ASTM C618, Class F or N, and the following additional requirements:

- a. The strength activity index at 28 days of age must be at least 95 percent of the control specimens.
- b. The average particle size must not exceed 6 microns.

#### 2.1.1.4 Slag

ASTM C989/C989M, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120. Certificates must include test results in accordance with ASTM C989/C989M.

#### 2.1.1.5 Supplementary Cementitious Materials (SCM) Content

The concrete mix must always contain one of the SCMs listed in Table 509.2.2.2:1 within the range specified therein, whether or not the aggregates are found to be reactive in accordance with the paragraph ALKALI REACTIVITY TEST".

#### 2.1.2 Water

Water must conform to ASTM C1602/C1602M. Hot water must not be used unless approved by the Contracting Officer.

#### 2.1.3 Aggregate

Coarse aggregate must consist of crushed or uncrushed gravel, crushed stone, or a combination thereof. Aggregates, as delivered to the mixers, must consist of clean, hard, uncoated particles. Coarse aggregate must be washed. Washing must be sufficient to remove dust and other coatings. Fine aggregate must consist of natural sand, manufactured sand, or a combination of the two, and must be composed of clean, hard, durable particles. Both coarse and fine aggregates must meet the requirements of ASTM C33/C33M and gradation requirements of Section 509 of the NMDOT Standard Specifications.

##### 2.1.3.1 Alkali Reactivity Test

Aggregates to be used in all concrete in projects over 50,000 SF in size must be evaluated and tested for alkali-aggregate reactivity in accordance with ASTM C1260. The types of aggregates must be evaluated in a combination which matches the proposed mix design (including Class F fly ash or GGBF slag), utilizing ASTM C1567. Test results of the combination must have a measured expansion of less than 0.08 percent at 28 days. Should the test data indicate an expansion of greater than 0.08%, the aggregate(s) must be rejected and new aggregate sources must be submitted for retesting or may submit additional test results incorporating Lithium Nitrate for consideration.

ASTM C1567 must be performed as follows to include one of the following



options:

- a. Utilize the low alkali Portland cement and Class F fly ash in combination for the test proportioning. The laboratory must use the Contractor's proposed percentage of cement and fly ash.
- b. Utilize the low alkali Portland cement and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory must use the Contractor's proposed percentage of cement and GGBF.
- c. Utilize the low alkali Portland cement and Class F fly ash and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory must use the Contractor's proposed percentage of cement, fly ash and GGBF.

#### 2.1.3.2 Fine Aggregates

ASTM C33/C33M.

#### 2.1.3.3 Coarse Aggregates

ASTM C33/C33M.

#### 2.1.4 Admixtures

ASTM C494/C494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures. Where not shown or specified, the use of admixtures is subject to written approval of the Contracting Officer.

ASTM C260/C260M: Air-entraining.

#### 2.1.5 Reinforcement

##### 2.1.5.1 Dowel Bars

Bars must conform to ASTM A615/A615M, Grade 60 for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars.

##### 2.1.5.2 Coated Dowel Bars

Bars must conform to ASTM A615/A615M, Grade 60 for plain billet-steel bars of the size and length indicated. Remove all burrs or projections from the dowel bars. Coating system must conform to AWWA C215, Type 2. Coat the bars with a double coat system or an epoxy coating system for resistance to penetration of oil and salt solutions. The systems must be in accordance with manufacturer's recommendation for coatings which are not bondable to concrete. Bond the coating to the dowel bar to resist laps or folds during movement of the joint. Coating thickness must be 7 mils minimum and 20 mils maximum.

##### 2.1.5.3 Tie Bars

Bars must be billet or axle steel deformed bars and conform to ASTM A615/A615M or ASTM A966/A966M Grade 40 or Grade 60. Epoxy coated in accordance with ASTM A775/A775M.

#### 2.1.5.4 Reinforcement

Deformed steel bar mats must conform to ASTM A184/A184M. Bar reinforcement must conform to ASTM A615/A615M and ASTM A966/A966M, Grade 60.

#### 2.1.6 Curing Materials

##### 2.1.6.1 White-Burlap-Polyethylene Sheet

ASTM C171, 0.004 inch thick white opaque polyethylene bonded to 10 oz/linear yard (40 inch) wide burlap.

##### 2.1.6.2 Liquid Membrane-Forming Compound

ASTM C309, white pigmented, Type 2, Class B, free of paraffin or petroleum.

##### 2.1.6.3 Liquid Chemical Sealer-Hardener Compound

Compound must be magnesium fluosilicate which when mixed with water seals and hardens the surface of the concrete. Do not use on exterior slabs exposed to freezing conditions. Compound must not reduce the adhesion of resilient flooring, tile, paint, roofing, waterproofing, or other material applied to concrete.

#### 2.1.7 Joint Fillers and Sealants

Provide as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS. New joints must match existing alignment.

#### 2.1.8 Biodegradable Form Release Agent

Provide form release agent that is colorless and biodegradable. A minimum of 87 percent of the total product must be biobased material. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent that does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

### 2.2 CONCRETE PAVEMENT

#### 2.2.1 Joint Layout Drawings

If jointing requirements on the project drawings are not compatible with the proposed placement sequence, submit a joint layout plan shop drawing to the Contracting Officer for approval. No work must be allowed to start until the joint layout plan is approved. The joint layout plan must indicate and describe in the detail the proposed jointing plan for contraction joints, expansion joints, and construction joints, in accordance with the following:

- a. Indicate locations of contraction joints, construction joints, and expansion joints. Spacing between contraction joints must not exceed 15 feet unless noted otherwise or approved by the Contracting Officer.
- b. The larger dimension of a panel must not be greater than 125% of the smaller dimension.
- c. The minimum angle between two intersecting joints must be 80 degrees,

unless noted otherwise or approved by the Contracting Officer.

- d. Joints must intersect pavement-free edges at a 90 degree angle the pavement edge and must extend straight for a minimum of 1.5 feet from the pavement edge, where possible.
- e. Align joints of adjacent panels.
- f. Align joints in attached curbs with joints in pavement when possible.
- g. Ensure joint depth, widths, and dimensions are specified.
- h. Minimum contraction joint depth must be 1/4 of the pavement thickness. The minimum joint width must be 1/8 inch.
- i. Use expansion joints only where pavement abuts buildings, foundations, manholes, and other fixed objects.

## 2.3 CONTRACTOR-FURNISHED MIX DESIGN

Contractor-furnished concrete mix must be designed in accordance with Section 509 of the NMDOT Standard Specifications.

## PART 3 EXECUTION

### 3.1 FORMS

#### 3.1.1 Construction

Construct forms to be removable without damaging the concrete.

#### 3.1.2 Coating

Before placing the concrete, coat the contact surfaces of forms except existing pavement sections where bonding is required, with a non-staining mineral oil, non-staining form coating compound, biodegradable form release agent, or two coats of nitro-cellulose lacquer. When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed.

#### 3.1.3 Grade and Alignment

Check and correct grade elevations and alignment of the forms immediately before placing the concrete.

### 3.2 REINFORCEMENT

#### 3.2.1 Dowel Bars

Install bars accurately aligned, vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Before installation thoroughly grease the sliding portion of each dowel. Dowels must remain in position during concrete placement and curing.

#### 3.2.2 Coated Dowel Bars

Install bars, accurately aligned vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Reject coatings which are perforated, cracked or otherwise damaged. While handling avoid

scuffing or gouging of the coatings.

### 3.2.3 Tie Bars

Install bars, accurately aligned horizontally and vertically, at indicated locations. For slipform construction, insert bent tie bars by hand or other approved means.

### 3.2.4 Setting Slab Reinforcement

Reinforcement must be positioned on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Reinforcement, when placed in concrete, must be free of mud, oil, scale or other foreign materials. Place reinforcement accurately and wire securely. The laps at splices must be 12 inches minimum and the distances from ends and sides of slabs and joints must be as indicated.

## 3.3 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

### 3.3.1 Measuring

ASTM C94/C94M.

### 3.3.2 Mixing

ASTM C94/C94M, except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 85 degrees F, place concrete within 60 minutes. With the approval of the Contracting Officer, a hydration stabilizer admixture meeting the requirements of ASTM C494/C494M Type D, may be used to extend the placement time to 90 minutes. Additional water may be added to bring slump within required limits as specified in Section 11.7 of ASTM C94/C94M, provided that the specified water-cement ratio is not exceeded.

### 3.3.3 Conveying

ASTM C94/C94M.

### 3.3.4 Placing

Follow guidance of ACI 301 and Sections 450 and 510 of the NMDOT Standard Specifications, except as modified herein. Do not exceed a free vertical drop of 5 feet from the point of discharge. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Do not place concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Place concrete continuously at a uniform rate, with minimum amount of segregation, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

### 3.3.5 Vibration

Immediately after spreading concrete, consolidate concrete with internal type vibrating equipment along the boundaries of all slabs regardless of

slab thickness, and interior of all concrete slabs 6 inches or more in thickness. Limit duration of vibration to that necessary to produce consolidation of concrete. Excessive vibration will not be permitted. Vibrators must not be operated in concrete at one location for more than 15 seconds. Vibrating equipment of a type approved by the Contracting Officer may be used to consolidate concrete in unreinforced pavement slabs less than 6 inches thick.

#### 3.3.5.1 Vibrating Equipment

Operate equipment, except hand-manipulated equipment, ahead of the finishing machine. Select the number of vibrating units and power of each unit to properly consolidate the concrete. Mount units on a frame that is capable of vertical movement and, when necessary, radial movement, so vibrators may be operated at any desired depth within the slab or be completely withdrawn from the concrete. Clear distance between frame-mounted vibrating units that have spuds that extend into the slab at intervals across the paving lane must not exceed 30 inches. Distance between end of vibrating tube and side form must not exceed 2 inches. For pavements less than 10 inches thick, operate vibrators at mid-depth parallel with or at a slight angle to the subbase. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 2 inches from subbase, and top of vibrator a few inches below pavement surface. Vibrators may be pneumatic, gas driven, or electric, and must be operated at frequencies within the concrete of not less than 8,000 vibrations per minute. Amplitude of vibration must be such that noticeable vibrations occur at 1.5 foot radius when the vibrator is inserted in the concrete to the depth specified.

#### 3.3.6 Cold Weather

Except with authorization, do not place concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 65 and 80 degrees F. Methods of heating materials are subject to approval of the Contracting Officer. Do not heat mixing water above 165 degrees F. Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306.1.

#### 3.3.7 Hot Weather

Maintain required concrete temperature in accordance with Figure NRMCA NOMOGRAPH FOR ESTIMATING EVAPORATION RATE ON THE BASIS OF MENZEL FORMULA in ACI 305.1 to prevent evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in ACI 305.1.

### 3.4 PAVING

Pavement must be constructed with paving and finishing equipment utilizing fixed forms or slipforms.

#### 3.4.1 Consolidation

The paver vibrators must be inserted into the concrete not closer to the underlying material than **2 inches**. The vibrators or tamping units in front of the paver must be automatically controlled so that they stop immediately as forward motion ceases. Excessive vibration must not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment must be vibrated with a hand-operated immersion vibrator. Vibrators must not be used to transport or spread the concrete.

#### 3.4.2 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions must be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates must overlap the existing pavement the minimum possible, but in no case more than **8 inches**.

#### 3.4.3 Required Results

The paver-finisher must be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation must produce a surface finish free of irregularities, tears, voids of any kind, and other discontinuities. It must produce only a minimum of paste at the surface. Multiple passes of the paver-finisher must not be permitted. The equipment and its operation must produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), must be applied to the concrete surface during paving and finishing.

#### 3.4.4 Fixed Form Paving

Forms must be steel, except that wood forms may be used for curves having a radius of **150 feet** or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form must be not less than eight-tenths of the vertical height of the form, except that forms **8 inches** or less in vertical height must have a base width not less than the vertical height of the form. Wood forms for curves and fillets must be adequate in strength and rigidly braced. Forms must be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms must not be set on blocks or on built-up spots of underlying material. Forms for overlay pavements and for other locations where forms must be set on existing pavements must be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes must be carefully drilled without cracking or spalling the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved. Forms must remain in place at least 12 hours after the concrete has been placed. Forms must be removed without injuring the concrete.

#### 3.4.5 Slipform Paving

The slipform paver must shape the concrete to the specified and indicated cross section in one pass, and must finish the surface and edges so that only a very minimum amount of hand finishing is required. Dowels must not be installed by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete.

#### 3.4.6 Placing Reinforcing Steel

Reinforcement must be positioned on suitable chairs securely fastened to the subgrade prior to concrete placement.

#### 3.4.7 Placing Dowels and Tie Bars

Dowels must be installed with alignment not greater than  $1/8$  inch per ft. Except as otherwise specified below, location of dowels must be within a horizontal tolerance of plus or minus  $5/8$  inch and a vertical tolerance of plus or minus  $3/16$  inch. The portion of each dowel intended to move within the concrete or expansion cap must be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. Dowels and tie bars in joints must be omitted when the center of the dowel and tie bar is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

##### 3.4.7.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane must be held securely in place by means of rigid metal basket assemblies. The dowels and tie bars must be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies must be held securely in the proper location by means of suitable anchors.

##### 3.4.7.2 Construction Joints-Fixed Form Paving

Installation of dowels and tie bars must be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

##### 3.4.7.3 Dowels Installed in Hardened Concrete

Installation must be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately  $1/8$  inch greater in diameter than the dowels must be drilled into the hardened concrete. Dowels must be bonded in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded 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. The dowels must be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels must be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars must be installed at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, a

standard keyway must be constructed, and the bent tie bars must be inserted into the plastic concrete through a 26 gauge thick metal keyway liner. Tie bars must not be installed in preformed holes. The keyway liner must be protected and must remain in place and become part of the joint. Before placement of the adjoining paving lane, the tie bars must be straightened, without spalling the concrete around the bar.

#### 3.4.7.4 Expansion Joints

Dowels in expansion joints must be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

### 3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times. Transverse and longitudinal surface tolerances must not exceed 1/4 inch in 10 feet.

#### 3.5.1 Side Form Finishing

Strike off and screed concrete to the required crown slope and cross-section by a power-driven transverse finishing machine. Transverse rotating tube or pipe is not permitted unless approved by the Contracting Officer. Elevation of concrete must be such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with two screeds which are readily and accurately adjustable for changes in pavement crown slope and compensation for wear and other causes. Make as many passes over each area of pavement and at such intervals as necessary to give proper compaction, retention of coarse aggregate near the finished surface, and a surface of uniform texture, true to grade and crown slope. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

##### 3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length.

##### 3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 0.02 foot. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

##### 3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished pavement



surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template.

#### 3.5.1.4 Longitudinal Floating

After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats. Use floats that are not less than 12 feet long and 6 inches wide and stiffened to prevent flexing and warping.

#### 3.5.2 Texturing

Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement must be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, Contracting Officer representative, and a representative of the Using Agency must inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces must be thoroughly power broomed to remove all debris. Transverse texturing must produce grooves in straight lines across each lane within a tolerance of plus or minus 1/2 inch of a true line. The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement must be finished to provide a surface of the same texture as the surrounding area.

##### 3.5.2.1 Burlap Drag Finish

Before concrete becomes non-plastic, finish the surface of the slab by dragging on the surface a strip of clean, wet burlap measuring from 3 to 10 feet long and 2 feet wider than the width of the pavement. Select dimension of burlap drag so that at least 3 feet of the material is in contact with the pavement. Drag the surface so as to produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks.

##### 3.5.2.2 Surface Grooving

The areas indicated on the drawings must be grooved with a spring tine drag producing individual grooves 1/4 inch deep and 1/4 inch wide at a spacing between groove centerlines of 2 inches. These grooves must be cut perpendicular to the centerline. Before grooving begins, the concrete must be allowed to stiffen sufficiently to prevent dislodging of aggregate. Grooves must not be cut within 6 inches of a transverse joint or crack.

#### 3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of 1/8 inch. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Remaining edges must be smooth and true to line.

#### 3.5.4 Repair of Surface Defects

Follow guidance of [ACI 301](#).

### 3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Use White-Burlap-Polyethylene Sheet or liquid membrane-forming compound, except as specified otherwise herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded. Maintain temperature of air next to concrete above [40 degrees F](#) for the full curing periods.

#### 3.6.1 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap [12 inches](#). Make sheeting not less than [18 inches](#) wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (re-saturation and re-placing must take no longer than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

#### 3.6.2 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Total coverage for the two coats must be at least [one gallon](#) of undiluted compound per [200 square feet](#). Compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

##### 3.6.2.1 Protection of Treated Surfaces

Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

#### 3.6.3 Liquid Chemical Sealer-Hardener

Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's recommendations. Seal or cover joints and openings in which joint sealant is to be applied as required by the joint

sealant manufacturer. The sealer-hardener must not be applied until the concrete has been moist cured and has aged for a minimum of 30 days. Apply a minimum of two coats of sealer-hardener.

### 3.7 FIELD QUALITY CONTROL

#### 3.7.1 Sampling

The Contractor's approved laboratory must collect samples of fresh concrete in accordance with [ASTM C172/C172M](#) during each working day as required to perform tests specified herein. Make test specimens in accordance with [ASTM C31/C31M](#).

#### 3.7.2 Consistency Tests

The Contractor's approved laboratory must perform [concrete slump tests](#) in accordance with [ASTM C143/C143M](#). Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every [20 cubic yards](#) (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams and cylinders are made.

#### 3.7.3 Flexural Strength Tests

The Contractor's approved laboratory must test for flexural strength in accordance with [ASTM C78/C78M](#). Make four test specimens for each set of tests. Test two specimens at 7 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28-day test results equals or exceeds the specified 28-day flexural strength, and no individual strength test is less than [550 pounds per square inch](#). If the ratio of the 7-day strength test to the specified 28-day strength is less than 65 percent, make necessary adjustments for conformance. Frequency of flexural tests on concrete beams must be not less than four test beams for each [50 cubic yards](#) of concrete, or fraction thereof, placed. Concrete which is determined to be defective, based on the strength acceptance criteria therein, must be removed and replaced with acceptable concrete.

#### 3.7.4 Air Content Tests

Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with [ASTM C231/C231M](#) on samples taken during placement of concrete in forms.

#### 3.7.5 Surface Testing

Surface testing for surface smoothness, edge slump and plan grade must be performed as indicated below by the Testing Laboratory. The measurements must be properly referenced in accordance with paving lane identification and stationing, and a report given to the Contracting Officer within 24 hours after measurement is made. A final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, must be provided to the Contracting Officer upon conclusion of surface testing.

##### 3.7.5.1 Surface Smoothness Requirements

Surface smoothness must be measured every [500 square feet](#). The finished

surfaces of the pavements must have no abrupt change of 1/8 inch or more, and all pavements must be within the tolerances specified when checked with a 12 foot straightedge: 1/5 inch longitudinal and 1/4 inch transverse directions for roads and streets and 1/4 inch for both directions for other concrete surfaces, such as parking areas.

#### 3.7.5.2 Surface Smoothness Testing Method

The surface of the pavement must be tested with the straightedge to identify all surface irregularities exceeding the tolerances specified above. The straightedge must be 12 feet and be constructed of aluminum or other lightweight metal and must have blades of box or box-girder cross section with flat bottom reinforced to ensure rigidity and accuracy. Straightedges must have handles to facilitate movement on pavement. The entire area of the pavement must be tested in both a longitudinal and a transverse direction on parallel lines approximately 15 feet apart. The straightedge must be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity must be determined by placing the 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.

#### 3.7.6 Plan Grade Testing and Conformance

The surfaces must vary not more than 0.06 foot above or below the plan grade line or elevation indicated. Each pavement category must be checked for conformance with plan grade requirements by running lines of levels at intervals to determine the elevation at each joint intersection.

#### 3.7.7 Test for Pavement Thickness

Measure thickness of pavement during placement with a ruler or take full depth cores of 4-inch diameter of concrete pavement every 500 square feet in accordance with ASTM C42/C42M. Measure thickness in accordance with ASTM C1542/C1542M. Record and submit testing, inspection, and evaluation of each core for surface paste, uniformity of aggregate distribution, segregation, voids, cracks, and depth of reinforcement or dowel (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, rotating the core approximately 120 degrees between photographs. Include a ruler for scale in the photographs. Submit plan view of location for each core.

#### 3.7.8 Reinforcement

Inspect reinforcement prior to installation to assure it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

#### 3.7.9 Dowels

Inspect dowel placement prior to placing concrete to assure that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Dowels must not deviate from vertical or horizontal alignment after concrete has been placed by more than 1/8 inch per foot.

-- End of Section --

SECTION 32 13 73

COMPRESSION JOINT SEALS FOR CONCRETE 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.

ASTM INTERNATIONAL (ASTM)

ASTM D2628 (1991; R 2016) Standard Specification for  
Preformed Polychloroprene Elastomeric  
Joint Seals for Concrete Pavements

ASTM D2835 (1989; R 2017) Standard Specification for  
Lubricant for Installation of Preformed  
Compression Seals in Concrete Pavements

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

SD-03 Product Data

Equipment

Manufacturer's Instructions

SD-04, Samples

Compression Seals; G

SD-06 Test Reports

Test Requirements

1.3 QUALITY ASSURANCE

1.3.1 Safety

Do not place compression joint seals within 25 feet of liquid oxygen (LOX) equipment, LOX storage, or LOX piping.

1.3.2 Trial Joint Seal and Lubricant/Adhesive Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 200 feet long at a designated location in the project pavement, using the specified materials and the approved

equipment to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the trial length and before any other joint is sealed, the trial joints will be inspected by the Government to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements, remove the materials, and the joints shall be recleaned and resealed at no cost to the Government. No other joints shall be sealed until the test installation has been approved. If the trial section is approved, it may be incorporated into the permanent work. Seal other joints in the manner approved for sealing the trial joint.

#### 1.4 DELIVERY, STORAGE, AND HANDLING

Materials delivered to the jobsite shall be inspected for defects, unloaded, and stored with a minimum of handling to avoid damage. Provide storage facilities that protect materials from weather and maintain materials at temperatures recommended by the manufacturer.

#### 1.5 ENVIRONMENTAL REQUIREMENTS

The ambient temperature and the pavement temperature within the joint wall shall be at least 35 degrees F and rising at the time of installation of the materials. Sealant installation will not be allowed if moisture or foreign material is observed in the joint.

### PART 2 PRODUCTS

#### 2.1 SYSTEM EQUIPMENT

Provide machines, tools, and equipment, used in the performance of the work required by this section, approved before the work is started and maintained in satisfactory condition at all times. Submit list of proposed equipment to be used in the performance of construction work, including descriptive data, 30 days prior to use on the project.

##### 2.1.1 Joint Cleaning Equipment

###### 2.1.1.1 Concrete Saw

Provide a self-propelled power saw with water-cooled diamond saw blades for cutting joints to the depths and widths specified and for removing filler, existing old joint seal, or other material embedded in the joints or adhered to the joint faces.

###### 2.1.1.2 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and a long-wearing venturi-type nozzle of proper size, shape, and opening. The maximum nozzle opening should not exceed 1/4 inch. Provide a portable air compressor capable of furnishing not less than 150 cubic feet per minute and maintaining a line pressure of not less than 90 psi at the nozzle while in use. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint about 1 inch above the pavement surface and will direct the blast to clean the joint walls. Adjust the height, angle of inclination, and the size of the nozzle as necessary to ensure satisfactory results.

#### 2.1.1.3 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, a wand with safety release cutoff controls, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary water resupply equipment shall be of sufficient capacity to permit continuous operations. The pumps, hoses, wand, and nozzle shall be of sufficient capacity to permit the cleaning of both walls of the joint and the pavement surface for a width of at least  $1/2$  inch on either side of the joint. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

#### 2.1.2 Sealing Equipment

Equipment used to install the compression seal shall place the compression seal to the prescribed depths within the specified tolerances without cutting, nicking, twisting, or otherwise damaging the seal. The equipment shall be capable of placing the seal with not more than two percent longitudinal stretch or compression of the seal during installation. The machine shall be an automatic self-propelled joint seal application equipment and engine powered. The machine shall include a reservoir for the lubricant/adhesive, a device for conveying the lubricant/adhesive in the proper quantities to the sides of the compression seal or the sidewalls of the joints, a reel capable of holding one full spool of compression seal, and a power-driven apparatus for feeding the joint seal through a compression device and inserting the seal into the joint. The equipment shall also include a guide to maintain the proper course along the joint being sealed. The machine shall at all times be operated by an experienced operator.

#### 2.1.3 Test Requirements

Submit certified copies of test results, 30 days prior to use of material on the project. Each lot of compression joint seal and lubricant/adhesive shall be sampled, identified, and tested for conformance with the applicable material specification.

- a. A lot of compression seal shall consist of 1 day's production or 20,000 linear feet for each cross section, whichever is less. A lot of lubricant/adhesive shall consist of 1 day's production. Samples of the compression joint seal and lubricant/adhesive material shall be submitted and will be tested by the Government. No material shall be used at the project prior to receipt of written notice that the materials meet the laboratory requirements.
- b. Testing of the compression joint seal and lubricant/adhesive material is the responsibility of the Contractor and shall be performed in an approved independent laboratory, and certified copies of the test reports shall be submitted for approval 30 days prior to the use of the materials at the jobsite.
- c. Samples of each lot of material shall also be submitted and will be retained by the Government for possible future testing should the materials appear defective during or after application. Furnish additional samples of materials, in sufficient quantity to be tested, upon request. Final acceptance will be based on conformance to the specified test requirements and the performance of the in-place materials.

## 2.2 COMPRESSION SEALS

Regardless of testing responsibility, submit 9 foot long samples of the materials, 60 days prior to use on the project. Printed directions from the manufacturer on recommended installation criteria shall be furnished with the samples plus the manufacturer's certification that the selected seal is recommended for the installation on this project. Compression joint seal materials shall be a vulcanized elastomeric compound using polychloroprene as the only base polymer. The material and manufactured seal shall conform to ASTM D2628. The joint seal shall be a labyrinth type seal. The uncompressed depth of the face of the compression seal (that is to be bonded to the joint wall) shall be greater than the uncompressed width of the seal, except that for seals 1 inch or greater in width, the depth need be only 1 inch or greater. The actual width of the uncompressed seal for construction and contraction joints shall be 0.75 or 1 inches and for expansion joints shall be 1.25 inches. The tolerance on the seal shall be plus 1/8 inch or minus 1/16 inch.

## 2.3 LUBRICANT/ADHESIVE

Lubricant/adhesive used for the compression elastomeric joint seal shall be a one-component compound conforming to ASTM D2835.

## PART 3 EXECUTION

### 3.1 PREPARATION OF JOINTS

Immediately before installation of the compression joint seal, thoroughly clean the joints to remove laitance, filler, existing sealer, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Cleaning shall be by sandblasting or waterblasting and shall extend along pavement surfaces at least 1/2 inch on either side of the joint. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water. Demonstrate that the selected cleaning operation meets the cleanliness requirements. Correct any irregularity in the joint face which would prevent uniform contact between the joint seal and the joint face prior to the installation of the joint seal.

#### 3.1.1 Sawing

Clean and open joints to the specified width and depth by sawing. Immediately following the sawing operation, thoroughly clean the joint faces and opening using a water jet to remove saw cuttings or debris remaining on the faces or in the joint opening. Install compression seal within 3 calendar days of the time the joint cavity is sawed. Depth of the joint cavity shall be in accordance with manufacturer's instructions. Where installation procedures are required in accordance with the manufacturer's recommendations, submit printed copies of manufacturers' instructions, 30 days prior to use on the project. The saw cut for the joint seal cavity shall be centered over the joint line. The nominal width of the sawed joint seal cavity shall be in accordance with the manufacturer's instructions.

- a. Measure the pavement temperature in the presence of the Contracting Officer. Make measurement each day before commencing sawing and at any other time during the day when the temperature appears to be varying from the allowable sawing range.



### 3.1.2 Sandblast Cleaning

Use a multiple pass sandblasting technique until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

### 3.1.3 Waterblast Cleaning

Use a multiple pass waterblast technique until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

### 3.1.4 Rate of Progress

Limit sandblasting or waterblasting of joint faces to the length of joint that can be sealed during the same workday.

## 3.2 INSTALLATION OF THE COMPRESSION SEAL

A representative of the joint seal manufacturer shall be present at the trial joint installation to correct any installation issues prior to full installation.

### 3.2.1 Time of Installation

Seal joints immediately within 3 calendar days of sawing the joint seal cavity and following concrete cure and the final cleaning of the joint walls. Provide open joints, ready for sealing that cannot be sealed under the specified conditions, with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, the joints shall be washed, air pressure cleaned, and allowed to dry prior to installing the lubricant/adhesive and compression seal.

### 3.2.2 Sequence of Installation

Seal first longitudinal joints, followed by transverse joints. Install seals in longitudinal joints so that all transverse joint seals will be intact from edge to edge of the pavement. Intersections shall be made monolithic by use of joint seal adhesive and care in fitting the intersection parts together. Extender pieces of seal shall not be used at intersections. Any seal falling short at the intersection shall be removed and replaced with new seal at no additional cost to the Government. Seals that are required to change direction by more than 20 degrees, may require a poured sealant at the intersection. Poured sealant shall be in accordance with compression seal manufacturer's instructions.

## 3.3 SEALING OF JOINTS

The sides of the joint seal or the sides of the joint shall be covered with a coating of lubricant/adhesive and the seal installed as specified. Butt joints and seal intersections shall be coated with liberal applications of lubricant/adhesive. Lubricant/adhesive spilled on the pavement shall be removed immediately to prevent setting on the pavement. The in-place joint seal shall be in an upright position and free from twisting, distortion, and cuts. Adjustments shall be made to the installation equipment and procedure, if the stretch exceeds 1 percent.

Any seal exceeding 2 percent stretch shall be removed and replaced. The joint seal shall be placed at a uniform depth within the tolerances specified. In-place joint seal which fails to meet the specified requirements shall be removed and replaced with new joint seal at no cost to the Government. The compression joint seal shall be placed to a depth of 1/4 inch, plus or minus 1/8 inch, below the pavement surface except when the joint is beveled or has a radius at the surface, or unless otherwise directed. For beveled joints or joints with a radius at the surface, the compression joint seal shall be installed at a depth of 1/8 inch, plus or minus 1/8 inch, below the bottom of the edge of the bevel or radius. No part of the seal shall be allowed to project above the surface of the pavement or above the edge of the bevel or radius. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections to provide continuous installation of the seal in the transverse joints. The lubricant/adhesive in the longitudinal joints shall be allowed to set for 1 hour prior to cutting at the joint intersections to reduce the possibility of shrinkage. For all transverse joints, the minimum length of the compression joint seal shall be the pavement width from edge to edge.

### 3.4 CLEAN-UP

Upon completion of the project, remove all unused materials from the site, remove any lubricant/adhesive on the pavement surface, and leave the pavement in clean condition.

### 3.5 QUALITY CONTROL PROVISIONS

#### 3.5.1 Application Equipment

Inspect the application equipment to assure uniform application of lubricant/adhesive to the sides of the compression joint seal or the walls of the joint. If any equipment causes cutting, twisting, nicking, excessive stretching or compressing of the seal, or improper application of the lubricant/adhesive, suspend the operation until causes of the deficiencies are determined and corrected.

#### 3.5.2 Procedures

##### 3.5.2.1 Quality Control Inspection

Provide quality control provisions during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damage the concrete in any manner. Cleaned joints shall be approved by the Government prior to installation of the lubricant/adhesive and compression joint seal.

##### 3.5.2.2 Conformance to Stretching and Compression Limitations

Determine conformance to stretching and compression limitations. Mark the top surface of the compression seal at 1 foot intervals in a manner clear and durable to enable length determinations of the seal. After installation, measure the distance between the marks on the seal. If the stretching or compression exceeds 2 percent, remove the seal and replace it with new joint at no additional cost to the Government. The seal shall be removed up to the last correct measurement. The seal shall be inspected a minimum of once per 400 feet of seal for compliance to the shrinkage or compression requirements. Measurements shall also be made at the same interval to determine conformance with depth and width of

installation requirements. Remove and replace compression seal that is not in conformance with specification requirements with new joint seal at no additional cost to the Government.

#### 3.5.2.3 Pavement Temperature

Determine the pavement temperature by placing a thermometer in the initial saw cut for the joint and record the reading. The thermometer shall remain in the joint for an adequate time to provide a control reading.

#### 3.5.3 Final Inspection

Inspect the joint sealing system (compression seal and lubricant/adhesive) for proper rate of cure and bonding to the concrete, cuts, twists, nicks and other deficiencies. Seals exhibiting any defects, at any time prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced in a satisfactory manner.

-- End of Section --

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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 (2016) Standard Specification for Deformed  
and Plain Carbon-Steel Bars for Concrete  
Reinforcement

ASTM A1064/A1064M (2017) Standard Specification for  
Carbon-Steel Wire and Welded Wire  
Reinforcement, Plain and Deformed, for  
Concrete

ASTM C31/C31M (2019) Standard Practice for Making and  
Curing Concrete Test Specimens in the Field

ASTM C94/C94M (2018) Standard Specification for  
Ready-Mixed Concrete

ASTM C143/C143M (2015) Standard Test Method for Slump of  
Hydraulic-Cement Concrete

ASTM C171 (2016) 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 (2017a) Standard Test Method for Air  
Content of Freshly Mixed Concrete by the  
Pressure Method

ASTM C309 (2011) Standard Specification for Liquid  
Membrane-Forming Compounds for Curing  
Concrete

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1751	(2004; E 2013; R 2013) 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 COMM	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities
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1.2 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. 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, ASTM C94/C94M 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 5 to 7 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.

## 2.6.5 Biodegradable Form Release Agent

Use form release agent that is colorless and biodegradable and that is composed of at least 87 percent biobased material. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent that does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

## 2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 COMM - 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 31 00 00 EARTHWORK. 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 of 1/4 inch per foot. Unless otherwise indicated, construct sidewalks that are located adjacent to curbs with the low side adjacent to the curb. 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  $5/16$  inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to  $1/4$  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  $1/2$  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  $1/4$  inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to  $1/4$  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 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 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 COMM, Section 705, and by manufacturers'



installation instructions.

-- End of Section --

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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 248 (1991; R 2012) Standard Specification for  
Ready-Mixed White and Yellow Traffic Paints

ASTM INTERNATIONAL (ASTM)

ASTM D4061 (2013) Standard Test Method for  
Retroreflectance of Horizontal Coatings

ASTM D4505 (2012; R 2017) Standard Specification for  
Preformed Retroreflective Pavement Marking  
Tape for Extended Service Life

ASTM D6628 (2003; R 2015) Standard Specification for  
Color of Pavement Marking Materials

ASTM E1710 (2011) Standard Test Method for  
Measurement of Retroreflective Pavement  
Marking Materials with CEN-Prescribed  
Geometry Using a Portable  
Retroreflectometer

ASTM E2177 (2011) Standard Test Method for Measuring  
the Coefficient of Retroreflected  
Luminance (RL) of Pavement Markings in a  
Standard Condition of Wetness

ASTM E2302 (2003; R 2016) Standard Test Method for  
Measurement of the Luminance Coefficient  
Under Diffuse Illumination of Pavement  
Marking Materials Using a Portable  
Reflectometer

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 (2019) 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) Paint, Traffic and Airfield  
Markings, Waterborne

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation;  
submittals not having a "G" designation are for information only or as  
otherwise designated. Submit the following in accordance with Section  
01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Surface Preparation Equipment List; G

Application Equipment List; G

Exterior Surface Preparation

Safety Data Sheets; G

Waterborne Paint; G

Solventborne Paint; G

SD-06 Test Reports

Waterborne Paint; G

Solventborne Paint; G

Test Reports

SD-07 Certificates

Qualifications; G

Waterborne Paint

Solventborne Paint

Volatile Organic Compound, (VOC); G

SD-08 Manufacturer's Instructions

Waterborne Paint; G

Solventborne Paint; G

### 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, only in areas approved by the Contracting Officer, for maintaining materials at temperatures recommended by the manufacturer. Make available paint stored at the project site or segregated at the source for sampling not less than 30 days prior to date of required approval for use to allow sufficient time for testing. Notify the Contracting Officer when paint is available for sampling.

### 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.

## PART 2 PRODUCTS

### 2.1 EQUIPMENT

#### 2.1.1 Surface Preparation and Paint Removal

##### 2.1.1.1 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.

##### 2.1.1.1.1 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.

##### 2.1.1.1.2 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.

##### 2.1.1.1.3 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.

##### 2.1.1.1.4 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.

#### 2.1.1.2 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.

###### 2.1.2.1.2 Self-Propelled or Mobile-Drawn Spraying Machines

###### 2.1.2.1.2.1 Road Marking

Provide equipment used for marking roads capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines, or a combination of solid and intermittent lines using a maximum of three different colors of paint as specified.

###### 2.1.2.1.2.2 Hand Application

Provide spray guns for hand application of paint in areas where the mobile paint applicator cannot be used.

#### 2.2 MATERIALS

Use non-reflectorized waterborne or solventborne 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 Solventborne Paint

[AASHTO M 248](#).

### 2.2.3 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.

### 2.2.4 Reflective Media

#### 2.2.4.1 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 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Retroreflectometer with a direct readout in millicandelas per square meter per lux (mcd/m<sup>2</sup>/lx). Perform testing in accordance with ASTM D4061, ASTM E1710, ASTM E2177, and ASTM E2302.

### 3.1.6 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 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.

### 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.

#### 3.3.1.1.1 Waterborne Paint

##### 3.3.1.1.1.1 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 Solventborne Paint

Apply paint at a minimum wet film thickness of 15 mils. Apply FS TT-B-1325 Type I (Gradation A) beads at a minimum rate of 6 pounds of glass spheres per gallon.

#### 3.3.2 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 materials and reflective media are available for sampling, obtain by random selection from the sealed containers, two 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.

Test samples by an approved laboratory. If a sample fails to meet specification, replace the material in the area represented by the samples and retest the replacement material as specified above. Submit certified copies of the test reports, prior to the use of the materials at the jobsite. Include in the report of test results a listing of any specification requirements not verified by the test laboratory. 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.

#### 3.4.6 Retroreflective Markings

Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m<sup>2</sup>/lx) (measured with Retroreflectometer). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m<sup>2</sup>/lx). Compute readings by averaging a minimum of 10 readings taken within the area at random locations. Re-mark areas not meeting the retroreflective requirements stated above.

-- End of Section --

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SECTION 32 31 13

CHAIN LINK FENCES 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 A90/A90M	(2013; R 2018) Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM A116	(2011) Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric
ASTM A153/A153M	(2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A702	(2013) Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM C94/C94M	(2018) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2014a) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014) Standard Specification for Fence Fittings
ASTM F883	(2013) Padlocks
ASTM F1043	(2018) Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
ASTM F1083	(2018) Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191/2	(Rev E) Fencing, Wire and Post, Metal (Chain-Link Fence Gates)
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FS RR-F-191/3

(Rev E; Am 1) Fencing, Wire and Post,  
Metal (Chain-Link Fence Posts, Top Rails  
and Braces)

FS RR-F-191/4

(Rev F) Fencing, Wire and Post, Metal  
(Chain-Link Fence Accessories)

## 1.2 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

### SD-02 Shop Drawings

Fence Assembly; G

Location of Gate, Corner, End, and Pull Posts; G

Gate Assembly; G

Gate Hardware and Accessories; G

Erection/Installation Drawings; G

### SD-03 Product Data

Fence Assembly; G

Gate Assembly; G

Gate Hardware and Accessories; G

Zinc Coating; G

Aluminum Alloy Coating; G

Fabric; G

Stretcher Bars; G

Concrete; G

### SD-04 Samples

Fabric; G

Posts; G

Braces; G

Line Posts; G

Sleeves; G

Top Rail; G

Bottom Rail; G

Tension Wire; G

Stretcher Bars; G

Gate Posts; G

Gate Hardware and Accessories; G

Padlocks; G

Wire Ties; G

#### SD-07 Certificates

Certificates of Compliance

#### SD-08 Manufacturer's Instructions

Fence Assembly

Gate Assembly

Hardware Assembly

Accessories

#### SD-11 Closeout Submittals

Recycled Material Content; S

### 1.3 QUALITY CONTROL

#### 1.3.1 Certificates of Compliance

Submit [certificates of compliance](#) in accordance with the applicable reference standards and descriptions of this section for the following:

- a. Zinc coating
- b. [Aluminum alloy coating](#)
- c. Fabric
- d. Stretcher bars
- e. Gate hardware and accessories
- f. Concrete

### 1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

## PART 2 PRODUCTS

### 2.1 SYSTEM DESCRIPTION

Provide fencing materials conforming to the requirements of ASTM A116, ASTM A702, ASTM F626.

Submit reports of listing chain-link fencing and accessories regarding weight in ounces for zinc coating.

Submit manufacturer's catalog data for complete fence assembly, gate assembly, hardware assembly and accessories.

### 2.2 COMPONENTS

#### 2.2.1 Fabric

Provide fabric consisting of No. 9-gage wires woven into a 1-3/4 inch diamond mesh, with dimensions of fabric and wire conforming to ASTM A116, with 1.20 ounces per square foot zinc galvanizing.

Provide one-piece fabric widths for fence heights up to 12 feet.

##### 2.2.1.1 Top and Bottom Selvages

Provide knuckled selvages at top and bottom for fabric with 2 inch mesh and up to 60 inches high, and if over 60 inches high, provide twisted and barbed top selvege and knuckled bottom selvege.

Knuckle top and bottom selvages for 1-3/4 inch and 1 inch mesh fabric.

#### 2.2.2 Posts, Rails and Braces

FS RR-F-191/3 line posts; Class 1, steel pipe, Grade A or B. End, corner, and pull posts; Class 1, steel pipe, Grade A or B. Braces and rails; Class 1, steel pipe, Grade A or B, in minimum sizes listed in FS RR-F-191/3 for each class and grade size.

#### 2.2.3 Line Posts

Minimum acceptable line posts are as follows:

Up to 6 feet high:

Grade A: 1.900 inch O.D. pipe weighing 2.72 pounds per linear foot.

Grade B: 2.375 inch O.D. pipe weighing 3.12 pounds per linear foot.

Over 6 feet high:

2.0 inch O.D. pipe weighing 3.65 pounds per linear foot.

#### 2.2.4 End, Corner, and Pull Posts

Provide minimally acceptable end, corner, and pull posts as follows:

Up to 6 feet high:

Grade A: 2.375 inch O.D. pipe weighing 3.65 pounds per linear foot.



Grade B: 2.375 inch O.D. pipe weighing 3.12 pounds per linear foot.

Over 6 feet high:

Grade A: 2.875 inch O.D. pipe weighing 5.79 pounds per linear foot.

Grade B: 2.875 inch O.D. pipe weighing 4.64 pounds per linear foot.

#### 2.2.5 Sleeves

Provide sleeves for setting into concrete construction of the same material as post sections, sized 1 inch greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

#### 2.2.6 Top Rail

Provide top rails with a minimum of 1.660 inches O.D. pipe rails. Grade A weighing 2.27 pounds per linear foot or Grade B weighing 1.82 pounds per linear foot. Provide expansion couplings 6 inches long at each joint in top rails.

#### 2.2.7 Center Rails Between Line Posts

For fencing over 6-feet high, provide 1.660 inches O.D. pipe center rails, Grade A weighing 2.27 pounds per linear foot or Grade B weighing 1.82 pounds per linear foot.

#### 2.2.8 Bottom Rail

Provide bottom rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized.

#### 2.2.9 Post-Brace Assembly

Provide bracing consisting of 1.660 inches O.D. pipe Grade A weighing 2.27 pounds per linear foot or Grade B weighing 1.82 pounds per linear foot and 3/8 inch adjustable truss rods and turnbuckles.

#### 2.2.10 Stretcher Bars

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 3/16 by 3/4 inch, in accordance with ASTM F626.

#### 2.2.11 Stretcher Bar Bands

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over 15 inches on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

#### 2.2.12 Post Tops

Provide tops that are steel, wrought iron, or malleable iron designed as a weathertight closure cap. Provide one cap for each post, unless equal protection is provided by a combination post-cap and wire supporting arm. Provide caps with an opening to permit through passage of the top rail.

### 2.2.13 Gate Posts

Provide a gate post for supporting each gate leaf as follows:

Up to 6-feet wide:

2.875 inch O.D. pipe Grade A weighing 5.79 pounds per linear foot or  
Grade B weighing 4.64 pounds per linear foot.

Over 6 feet wide and up to 13 feet wide:

2.875 inch O.D. pipe Grade A weighing 5.79 pounds per linear foot or  
Grade B weighing 4.64 pounds per linear foot.

### 2.2.14 Gates

FS RR-F-191/2; Type II, double swing. Shape and size of gate frame, as indicated. Framing and bracing members, round of steel alloy. Steel member finish, zinc-coated. Provide gate frames and braces of minimum sizes listed in FS RR-F-191/3 for each Class and Grade, except that steel pipe frames are a minimum of 1.90 inches o.d., 0.120 inches minimum wall thickness and aluminum pipe frames and intermediate braces are 1.869 inches o.d. minimum, 0.940 lb/ft of length. Gate fabric, is as specified for fencing fabric. Coating for steel latches, stops, hinges, keepers, and accessories, is galvanized. Provide fork or plunger bar type gate latches. Special gate frames, as indicated. Provide truss rods or intermediate braces for gate leaves less than 8 feet wide. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding is not permitted. Arrange padlocking latches to be accessible from both sides of gate, regardless of latching arrangement.

For gate leaves up to 6 feet high or 6 feet wide, provide perimeter gate frames of 1.66 inch O.D. pipe Grade A weighing 2.27 pounds per linear foot. Grade B weighing 1.82 pounds per linear foot.

For gate leaves over 6 feet high or 6 feet wide, provide perimeter gate frames of 1.90 inch O.D. pipe Grade A weighing 2.72 pounds per linear foot or Grade B weighing 2.28 pounds per linear foot.

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 15 inches. Attach hardware with rivets or by other means which provides equal security against breakage or removal.

Provide diagonal cross-bracing, consisting of 3/8 inch diameter adjustable-length truss rods on welded gate frames, where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

### 2.2.15 Gate Hardware and Accessories

Provide gate hardware and accessories that conforms to ASTM A116 and ASTM F626, and be as specified:

Provide malleable iron, forged steel, or pressed steel hinges to suit gate

size, non-lift-off type, offset to permit 180-degree opening.

Provide latch that permits operation from either side of the gate, with a padlock eye provided as an integral part of the latch.

Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

Provide double gates with a cane bolt and ground-set keeper, with latch or locking device and padlock eye designed as an integral part.

#### 2.2.16 Miscellaneous Hardware

Provide miscellaneous hot-dip galvanized hardware as required.

#### 2.2.17 Wire Ties

Provide 9-gage galvanized steel wire for tying fabric to line posts, spaced 12 inches on center. For tying fabric to rails and braces, space wire ties 24 inches on center. For tying fabric to tension wire, space 0.105-inch hog rings 24 inches on center.

Manufacturer's standard procedure will be accepted if of equal strength and durability.

FS RR-F-191/4. Provide wire ties constructed of the same material as the fencing fabric.

#### 2.2.18 Padlocks

Provide padlocks conforming to ASTM F883, with chain.

### 2.3 MATERIALS

#### 2.3.1 Zinc Coating

Provide hot-dip galvanized (after fabrication) ferrous-metal components and accessories, except as otherwise specified.

Provide zinc coating of weight not less than 1.94 ounces per square foot, as determined from the average result of two specimens, when tested in accordance with ASTM A90/A90M.

Provide zinc coating conforming to the requirements of the following:

- a. Pipe: FS RR-F-191/3 Class 1 Grade A in accordance with ASTM F1083 or Grade B in accordance with ASTM F1043.
- b. Hardware and accessories: ASTM A153/A153M, Table 1.
- c. Surface: ASTM F1043.
- d. External: Type B-B surface zinc with organic coating, 0.97 ounce per square foot minimum thickness of acrylated polymer.
- e. Internal: Surface zinc coating of 0.97 ounce per square foot minimum.

Provide galvanizing repair material that is cold-applied zinc-rich coating

conforming to ASTM A780/A780M.

#### 2.3.2 Tension Wire

Provide galvanized, coiled spring wire, No. 7-gage. Provide zinc coating that weighs not less than 2.0 ounces per square foot.

#### 2.3.3 Concrete

Provide concrete conforming to ASTM C94/C94M, and obtaining a minimum 28-day compressive strength of 3,000 psi.

#### 2.3.4 Grout

Provide grout of proportions one part portland cement to three parts clean, well-graded sand and a minimum amount of water to produce a workable mix.

### PART 3 EXECUTION

Submit manufacturer's erection/installation drawings and instructions that detail proper assembly and materials in the design for fence, gate, hardware and accessories.

Provide complete installation conforming to ASTM F567.

#### 3.1 PREPARATION

Ensure final grading and established elevations are complete prior to commencing fence installation.

##### 3.1.1 Clearing and Grading

Clear fence line of trees, brush, and other obstacles to install fencing for a distance of 5 feet inside; and 5 feet outside the fence. Establish a graded, compacted fence line prior to fencing installation.

#### 3.2 INSTALLATION

##### 3.2.1 Security

Install new chain link fencing, remove existing fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer and cognizant Security Officer.

##### 3.2.2 Fence Installation

Install fence on prepared surfaces to line and grade indicated. Secure fastening and hinge hardware in place to fence framework by peening or welding. Allow for proper operation of components. Coat peened or welded areas with a repair coating matching original coating. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

###### 3.2.2.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 10 feet on center. Provide gate posts spaced as necessary for size of gate

openings. Do not exceed 500 feet on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 15 degrees or more, or for abrupt changes in grade. Submit drawings showing location of gate, corner, end, and pull posts.

#### 3.2.2.2 Top and Bottom Tension Wire

Install top and bottom tension wires before installing chain-link fabric, and pull wires taut. Place top and bottom tension wires within 8 inches of respective fabric line.

#### 3.2.3 Excavation

Provide excavations for post footings which are drilled holes in virgin or compacted soil, of minimum sizes as indicated.

Space footings for line posts 10 feet on center maximum and at closer intervals when indicated, with bottoms of the holes approximately 3 inches below the bottoms of the posts. Set bottom of each post not less than 36 inches below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads.

Remove excavated soil from Government property.

When solid rock is encountered near the surface, drill into the rock at least 12 inches for line posts and at least 18 inches for end, pull, corner, and gate posts. Drill holes at least 1 inch greater in diameter than the largest dimension of the placed post.

If solid rock is below the soil overburden, drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

#### 3.2.4 Setting Posts

Remove loose and foreign materials from holes and moisten the soil prior to placing concrete.

Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved.

Grout all posts set into sleeved holes in concrete with an approved grouting material.

Maintain vertical alignment of posts in concrete construction until concrete has set.

##### 3.2.4.1 Earth and Bedrock

Provide concrete bases of dimensions indicated on the manufactures installation drawings, except in bedrock. Compact concrete to eliminate voids, and finish to a dome shape. In bedrock, set posts with a minimum of 1 inch of grout around each post. Work grout into hole to eliminate voids, and finish to a dome shape.

#### 3.2.4.2 Concrete Slabs and Walls

Set posts into zinc-coated sleeves, set in concrete slab or wall, to a minimum depth of 12 inches. Fill sleeve joint with lead, nonshrink grout, or other approved material. Set posts for support of removable fence sections into sleeves that provide a tight sliding joint and hold posts aligned and plumb without use of lead or setting material.

#### 3.2.4.3 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 12 inches below top of fence, and a diagonal tension rod two diagonal tension rods.

##### a. Tolerances

Provide posts that are straight and plumb within a vertical tolerance of 1/4 inch after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 1/2 inch deviation from the established centerline between line posts. Repair defects as directed.

#### 3.2.5 Concrete Strength

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

Take samples and test concrete to determine strength as specified.

#### 3.2.6 Top Rails

Provide top rails that run continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by the fencing manufacturer.

#### 3.2.7 Center Rails

Provide single piece center rails between posts set flush with posts on the fabric side, using special offset fittings where necessary.

#### 3.2.8 Brace Assembly

Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at midheight of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under proper tension.

Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

#### 3.2.9 Tension Wire Installation

Install tension wire by weaving them through the fabric and tying them to each post with not less than 7-gage galvanized wire or by securing the

wire to the fabric with 10-gage ties or clips spaced 24 inches on center.

#### 3.2.10 Fabric Installation

Provide fabric in single lengths between stretch bars with bottom barbs placed approximately 1-1/2 inches above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed.

Ensure fabric remains under tension after the pulling force is released.

#### 3.2.11 Stretcher Bar Installation

Thread stretcher bars through or clamped to fabric 4 inches on center and secured to posts with metal bands spaced 15 inches on center.

#### 3.2.12 Gate Installation

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

#### 3.2.13 Tie Wires

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

#### 3.2.14 Fasteners

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

#### 3.2.15 Zinc-Coating Repair

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

#### 3.2.16 Accessories Installation

##### 3.2.16.1 Post Caps

Design post caps to accommodate top rail. Install post caps as recommended by the manufacturer.

##### 3.2.16.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

#### 3.2.17 Grounding

Ground fencing as indicated on drawings and specified.

Ground all fences crossed by overhead power lines in excess of 600 volts, and all electrical equipment attached to the fence. 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. Grounding locations can not exceed 650 feet. Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by power lines of 600 volts or more at or near the point of crossing and at distances not exceeding 150 feet on each side of crossing. Provide ground conductor consisting of No. 6 AWG solid copper wire. Provide copper-clad steel rod grounding electrodes 3/4 inch by 10 foot long. 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, with top of the electrode not 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. Total resistance of the fence to ground cannot exceed 25 ohms.

### 3.3 CLOSEOUT ACTIVITIES

Remove waste fencing materials and other debris from the work site.

Submit manufacturer's data indicating percentage of recycled material content in protective fence materials, including chain link fence, fabric, and gates to verify affirmative procurement compliance.

-- 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 (2018) Standard Specification for  
Stainless Steel Wire

ASTM D2729 (2017) Standard Specification for  
Poly(Vinyl Chloride) (PVC) Sewer Pipe and  
Fittings

ASTM D3034 (2016) Standard Specification for Type PSM  
Poly(Vinyl Chloride) (PVC) Sewer Pipe and  
Fittings

ASTM D4427 (2018) Standard Classification of Peat  
Samples by Laboratory Testing

ASTM D4972 (2018) Standard Test Methods for pH of  
Soils

ASTM D5268 (2013) 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, 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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

State Landscape Contractor's License

Time Restrictions and Planting Conditions

Indicate anticipated dates and locations for each type of planting.

SD-03 Product Data

Peat

Composted Derivatives

Gypsum

Drainage Pipe

Mulch; G

Ground Stakes

Fertilizer

Weed Control Fabric; G

Root Control Barrier; G

Staking Material

Metal Anchors

Antidesiccants

Photographs; G

#### SD-04 Samples

##### Mulch; G

Submit one pint of mulch.

#### SD-06 Test Reports

Topsoil Composition Tests; Soil Test of current growing area; Soil Test of proposed area;

Percolation Test; Percolation Test of current growing area; Percolation Test of proposed area

#### 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 Soil 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 Plant Material Photographs

Contractor must submit nursery photographs, for government approval prior to ordering, for each tree larger than 24-inch box/ 2-inch caliper size.

#### 1.4.5 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 boxedballed and burlapped 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

Plant all plants from January 1 to December 31.

#### 1.6.2 Restrictions

Do not plant when ground is frozen, snow covered, muddy, or when air temperature exceeds 95 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.

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. Spray plants budding into leaf or having soft growth with an antidesiccant before digging. 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.

#### 2.1.3 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.

##### 2.1.4.1 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 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.

#### 2.1.5.4 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.

### 2.2 TOPSOIL

#### 2.2.1 Existing Soil

Modify to conform to requirements specified in paragraph COMPOSITION.

#### 2.2.2 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.

#### 2.2.3 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

#### 2.2.4 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.

### 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

Lime to meet topsoil test report recommendations.

#### 2.3.2 Aluminum Sulfate

Commercial grade.

#### 2.3.3 Sulfur

100 percent elemental

#### 2.3.4 Iron

100 percent elemental



#### 2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427 as modified herein. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation. Peat must not contain invasive species, including seeds.

#### 2.3.6 Sand

Clean and free of materials harmful to plants.

#### 2.3.7 Perlite

Horticultural grade.

#### 2.3.8 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:

##### 2.3.8.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

##### 2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

#### 2.3.9 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

Sandy topsoil: one part topsoil to one part peat; clay topsoil: two parts topsoil to one part peat. Thoroughly mix all parts of planting soil mixture to a uniform blend throughout.

#### 2.5 FERTILIZER

##### 2.5.1 Granular Fertilizer

Fertilizer follow soil test report recommendations.

##### 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.

## 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 DRAINAGE PIPE FOR PLANT PITS AND BEDS

Plastic polyvinyl chloride pipe, 4 inch inches in diameter, conforming to ASTM D3034 SDR 35 perforated conforming to ASTM D2729.

## 2.8 MULCH

Free from noxious weeds, mold, pesticides, or other deleterious materials.

### 2.8.1 Inert Mulch Materials

Provide stone, complying with ASTM D6155, as indicated on drawings.

## 2.9 STAKING AND GUYING MATERIAL

### 2.9.1 Staking Material

#### 2.9.1.1 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. Paint or stain wood stakes dark brown.

#### 2.9.1.2 Ground Stakes

Rough sawn hard wood or plastic, 2 inches square are by 3 feet long, pointed at one end.

### 2.9.2 Guying Material

#### 2.9.2.1 Guying Wire

12 gauge annealed galvanized steel, ASTM A580/A580M.

#### 2.9.2.2 Guying Cable

Minimum five-strand, 3/16 inch diameter galvanized steel cable.

### 2.9.3 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.

### 2.9.4 Flags

White surveyor's plastic tape, 6 inches long, fastened to guying wires or cables.

#### 2.9.5 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.

#### 2.9.6 Deadmen

4 by 8 inch rectangular or 8 inch diameter by 36 inch long, pine wood material.

#### 2.9.7 Metal Anchors

##### 2.9.7.1 Driven Anchors

Malleable iron, arrow shaped, galvanized, sized as follows:

<u>Tree Caliper</u>	<u>Anchor Size</u>
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

##### 2.9.7.2 Screw Anchors

Steel, screw type with welded-on 3 inch round helical steel plate, minimum 3/8 inch diameter, 15 inches long.

#### 2.10 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.

#### 2.11 ROOT CONTROL BARRIER

Pre-formed, linear 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 and Landscape Architect of Record 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 and soil amendments prior to planting. Provide tree, shrub, sod planting, post-planting fertilizer, edging, staking, guying, weed control fabric, 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 24 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 project site.

#### 3.2.2.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

#### 3.2.2.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

### 3.2.3 Root Control Barrier

Install linear polypropylene barrier a minimum 1/2 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.

### 3.2.4 Subsoil Drainage for Plant Pits and Beds

Provide as indicated. Lay perforated drain pipe with perforations down. Backfill trenches as specified in Section 31 00 00 EARTHWORK.

## 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. Set plants on native soil 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 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.

#### 3.4.3.4 Ground Covers and Vines

Smooth planting areas before planting to provide even, smooth finish. Plant after placing weed control fabric and mulch topdressing. Do not remove plant material from flats or containers until immediately before planting. Space at the intervals indicated. Plant at a depth to sufficiently cover all roots. 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 6 inches without run off or puddling. Add mulch topdressing as needed.

#### 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 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 2 inches.

#### 3.4.7 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 2 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.

#### 3.4.8 Fertilization

##### 3.4.8.1 Fertilizer Tablets

Place fertilizer planting tablets evenly spaced around the plant pits to the manufacturer's recommended depth.

##### 3.4.8.2 Granular Fertilizer

Apply granular fertilizer as a top coat prior to placing mulch layer and water thoroughly.

#### 3.4.9 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.

#### 3.4.10 Staking and Guying

##### 3.4.10.1 Staking

Stake plants with the number of stakes indicated complete with double strand of 12 gauge guy wire as detailed. Tree stakes to be 5-1/2 feet by 3-1/2 inches by 1-3/4 inches Steel T-Post; two coats of protective Green enamel with prime coat finish for rust protection; Tightly-welded anchor plate minimizes sideways or rotational movement; Studded design is strong and secures fence fabric and prevents t-post clips and insulators from slipping; Medium weight of 1-1/4 lb. per ft. 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 Pruning

Prune in accordance with safety requirement of TCIA Z133.

##### 3.4.11.1 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 in accordance with TCIA A300P1.

##### 3.4.11.2 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 --

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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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS  
(AASHTO)

AASHTO HB-17 (2002; Errata 2003; Errata 2005, 17th  
Edition) Standard Specifications for  
Highway Bridges

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300 (2010; Addenda 2011) Hypochlorites

AWWA B301 (2010) Liquid Chlorine

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

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

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

AWWA C153/A21.53 (2011) Ductile-Iron Compact Fittings for  
Water Service

AWWA C500 (2009) Metal-Seated Gate Valves for Water  
Supply Service

AWWA C502 (2018) Dry-Barrel Fire Hydrants

AWWA C503 (2018) Wet-Barrel Fire Hydrants

AWWA C504 (2015) Standard for Rubber-Seated  
Butterfly Valves

AWWA C508 (2017) Swing-Check Valves for Waterworks  
Service, 2 In. Through 48-In. (50-mm  
Through 1,200-mm) NPS

AWWA C509 (2015) Resilient-Seated Gate Valves for  
Water Supply Service

AWWA C515 (2015) Reduced-Wall, Resilient-Seated Gate  
Valves for Water Supply Service

AWWA C550	(2017) Protective Interior Coatings for Valves and Hydrants
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C605	(2014) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C655	(2009) Field Dechlorination
AWWA C800	(2014) 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 C906	(2015) Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 65 In., (1,575 mm) for Water Distribution and Transmission
AWWA M9	(2008; Errata 2013) Manual: Concrete Pressure Pipe
AWWA M11	(2016) Steel Pipe: A Guide for Design and Installation
AWWA M23	(2002; 2nd Ed) Manual: PVC Pipe - Design and Installation
AWWA M41	(2009; 3rd Ed) Ductile-Iron Pipe and Fittings
AWWA M55	(2006) PE Pipe - Design and Installation

ASME INTERNATIONAL (ASME)

ASME B16.1	(2015) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, 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

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B61	(2015) Standard Specification for Steam or Valve Bronze Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM C94/C94M	(2018) Standard Specification for Ready-Mixed Concrete
ASTM C1433	(2016b) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM D1784	(2011) 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 D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(2015) Standard Practice for Making

	Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3035	(2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM F402	(2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F714	(2013) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F1674	(2011) Standard Test Method for Joint Restraint Products for Use with PVC Pipe
ASTM F2164	(2013/2018) Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)	
FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies
FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control
MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)	
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 24	(2016; ERTA 2016) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NSF INTERNATIONAL (NSF)	
NSF 372	(2016) Drinking Water System Components - Lead Content
NSF/ANSI 14	(2018) Plastics Piping System Components and Related Materials
NSF/ANSI 61	(2019) Drinking Water System Components -

Health Effects

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-600-01 (2016; with Change 3, 2019) Fire  
Protection Engineering for Facilities

UNDERWRITERS LABORATORIES (UL)

UL 246 (2011; Reprint Dec 2018) UL Standard for  
Safety Hydrants for Fire-Protection Service

UL 262 (2004; Reprint Oct 2011) Gate Valves for  
Fire-Protection Service

UL 312 (2010; Reprint Mar 2018) UL Standard for  
Safety Check 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" 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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Connections; G

SD-03 Product Data

Pipe, Fittings, Joints and Couplings; G

Valves; G

Valve Boxes; G

Fire Hydrants; G

Pipe Restraint; G

Tapping Sleeves; G

Corporation Stops; G

Backflow Preventer; G

Precast Concrete Thrust Blocks; G

Disinfection Procedures; G

#### SD-06 Test Reports

Backflow Preventer Tests; G

Bacteriological Samples; G

Hydrostatic Sewer Test

Leakage Test

Hydrostatic Test

#### SD-07 Certificates

Pipe, Fittings, Joints and Couplings

Lining for Fittings

Valves

Fire Hydrants

Backflow Prevention Training Certificate

Backflow Tester Certification

Fusion Technician Qualifications; G

#### SD-08 Manufacturer's Instructions

PVC Piping

PVC Piping For Service Lines

### 1.4 QUALITY CONTROL

#### 1.4.1 Regulatory Requirements

Comply with NSF/ANSI 14 or NSF/ANSI 61 and NSF 372 for materials for potable water systems; comply with lead content requirements for "lead-free" plumbing as defined by the U.S. Safe Drinking Water Act

effective January 2014. Provide materials bearing the seal of the National Sanitation Foundation (NSF) for potable water service.

Comply with NFPA 24 for materials, installation, and testing of fire main piping and components.

#### 1.4.2 Qualifications

##### 1.4.2.1 Backflow Preventers

###### 1.4.2.1.1 Backflow Preventer Certificate

Certificate of Full Approval from FCCCHR List, University of Southern California, attesting that the design, size and make of each backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. Certificate of Provisional Approval will not be acceptable.

###### 1.4.2.1.1.1 Backflow Tester Certificate

Prior to testing, submit to the Contracting Officer certification issued by the State or local regulatory agency attesting that the backflow tester has successfully completed a certification course sponsored by the regulatory agency. Tester must not be affiliated with any company participating in any other phase of this Contract.

###### 1.4.2.1.1.2 Backflow Prevention Training Certificate

Submit a certificate recognized by the State or local authority that states the Contractor has completed at least 10 hours of training in backflow preventer installations. The certificate must be current.

#### 1.4.2.2 Fusion Technician Qualifications

Submit a certificate from the manufacturer of the fusible pipe that shows the fusion technician is fully qualified to install fusible pipe of the types and sizes being used. Qualification must be current as of the actual date of fusion performance on the project.

### 1.5 DELIVERY, STORAGE, AND HANDLING

#### 1.5.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling and in accordance with manufacturer's instructions. 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.

#### 1.5.2 Handling

Handle pipe, fittings, valves, fire hydrants, and other accessories in accordance with 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 and PVC-O pipe, fittings, and accessories in accordance with AWWA C605. Handle PE pipe, fittings, and accessories in accordance with AWWA M55.

## PART 2 PRODUCTS

### 2.1 MATERIALS

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 Plastic Piping

##### 2.1.1.1.1 PVC Piping

##### 2.1.1.1.1.1 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), 165 (DR25), 200 (DR21), 235 (DR 18), 250 (DR17) 305 (DR 14) with ductile iron outside diameter (DIOD).

##### 2.1.1.1.1.2 Fittings for PVC Pipe

Gray iron or ductile iron fittings, AWWA C110/A21.10 with special fittings in accordance with Appendix B or 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.

##### 2.1.1.1.1.3 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.

#### 2.1.1.1.2 PVC Piping for Service Lines

##### 2.1.1.1.2.1 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.

##### 2.1.1.1.2.2 Joints and Connections

Fittings may be joined by the solvent-cement method or threading.

##### 2.1.1.1.2.3 Solvent Joining

Provide solvent joints in accordance with ASTM D2855.

##### 2.1.1.1.3 Polyethylene (PE) Pipe

AWWA C906, ASTM D3035, PE4710, material designation code CC2 or CC3 with a minimum Pressure Class 250 (DR 9) with ductile iron outside diameter (DIOD).

##### 2.1.1.1.3.1 Fittings For PE Pipe

AWWA C906, AWWA M55, ASTM D3035, molded and manufactured to comply with ASTM F714.

##### 2.1.1.1.3.2 Joints and Jointing Materials

Mechanical Joint: AWWA C111/A21.11 DIOD Mechanical joint adapter and gaskets for mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories.

#### 2.1.2 Valves

Provide a protective interior coating in accordance with AWWA C550.

#### 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 or resilient-seated gate valves 3 to 12 inches in size.
- 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 0-ring stem seals, except for those valves for which gearing is specified, in which case use conventional packing in place of 0-ring seal. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Use gate valves with special ends for connection to cement piping or sleeve-type mechanical coupling in lieu of mechanical-joint ends and push-on joint ends. Provide valve ends and gaskets for connection to cement piping or to sleeve-type mechanical couplings that conform to the requirements specified respectively 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) and Aboveground Locations

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

- a. AWWA C500: solid-wedge gates and flanged ends.
- b. AWWA C509 or AWWA C515: nonrising stem type with flanged ends.
- c. UL 262: inside-screw type, with solid or one-piece 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. Gate valves are nonrising stem type or inside-screw type. Gate valves are solid-wedge gates or solid or one-piece type gates. 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. Provide all valves from one manufacturer.

#### 2.1.2.3 Check Valves

Provide a protective interior coating in accordance with AWWA C550. Swing-check type, AWWA C508 or UL 312 and:

- a. AWWA C508: Iron or steel body and cover and flanged ends
- b. UL 312: Cast iron or steel body and cover, flanged ends, and designed for a minimum working pressure of 150 psi.

Materials for [UL 312](#) check valves are to match the reference standards specified in [AWWA C508](#). Provide check valves with a clear port opening. Provide spring-loaded check valves where indicated. Class 125 flanges are to match [ASME B16.1](#). Provide grooved or shouldered ends, grooved or shouldered type joints, as specified in the paragraph [DUCTILE-IRON PIPING in lieu of flanged ends](#). Provide all check valves from one manufacturer.

#### 2.1.1.2.4 Rubber-Seated Butterfly Valves

Provide rubber-seated butterfly valves and wafer type valves that match the performance requirements of [AWWA C504](#). Wafer type valves not meeting laying length requirements are acceptable if supplied and installed with a spacer, providing the specified laying length. Meet all tests required by [AWWA C504](#). Flanged-end valves are required in a pit. Provide a union or sleeve-type coupling in the pit to permit removal. Direct-bury mechanical-end valves [3 through 10 inches](#) in diameter. Provide a valve box, means for manual operation, and an adjacent pipe joint to facilitate valve removal. Provide valve operators that restrict closing to a rate requiring approximately 60 seconds, from fully open to fully closed.

#### 2.1.1.2.5 Water Service Valves

##### 2.1.1.2.5.1 Gate Valves Smaller than 3 Inch in Size on Buried Piping

Gate valves smaller than 3 inch size on Buried Piping [MSS SP-80](#), Class 150, solid wedge, nonrising stem, with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

##### 2.1.1.2.5.2 Gate Valves Smaller Than 3 Inch Size in Valve Pits

[MSS SP-80](#), Class 150, solid wedge, inside screw, rising stem. Provide valves with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

#### 2.1.1.2.6 Valve Boxes

Provide a valve box for each gate valve on buried piping, except where indicator post is shown. Construct adjustable valve boxes manufactured from cast iron or precast concrete of a size compatible for the valve on which it is used. Provide cast iron valve boxes with a minimum cover and wall thickness of [3/16 inch](#) and conforming to [ASTM A48/A48M](#), Class 35B. Coat the cast-iron box with a heavy coat of bituminous paint. 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](#) as indicated. Provide [ASTM C1433](#) precast concrete valve box. Provide precast concrete boxes installed in locations subjected to vehicular traffic to withstand AASHTO load designation as outlined in [AASHTO HB-17](#).

#### 2.1.1.2.7 Valve Pits

Construct the valve pits at locations indicated or as required above and in accordance with the details shown.

#### 2.1.1.3 Blowoff Valve Assemblies

Provide blowoff valve assemblies complete with all pipe, fittings, valve, valve box, riser box and lid, riser extension, discharge fitting and other materials required to connect to the water main. Provide blow off valve assemblies [4 inches](#) or larger with [AWWA C110/A21.10](#) or [AWWA C153/A21.53](#)

fittings. Provide a blowoff valve assembly with a removable riser.

#### 2.1.4 Fire Hydrants And Hose Houses

##### 2.1.4.1 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.

Provide a protective epoxy interior coating conforming to [AWWA C550](#) on those portions of the fire hydrant continuously in contact with sea water or salt water.

##### 2.1.4.1.1 Dry-Barrel Type and Wet-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 Wet-barrel type fire hydrants, [AWWA C503](#) or [UL 246](#), "Wet Barrel" with 6 inch inlet, one 4 1/2 inch pumper connection, and two 2 1/2 inch hose connections. Individually valve pumper connection and hose connections with independent nozzle gate valves.

Provide mechanical-joint or push-on joint end inlet, except where flanged end is indicated; with end matching requirements as specified in [AWWA C502](#) or [AWWA C503](#) 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](#) breakable features as mentioned in [AWWA C503](#). Provide fire hydrant with special couplings joining upper and lower sections of fire hydrant barrel and upper and lower sections of fire hydrant stem that break from a force imposed by a moving vehicle.

#### 2.1.5 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 Thrust Blocks

Use [ASTM C94/C94M](#) concrete having a minimum compressive strength of 2,500 psi at 28 days or use concrete of a mix not leaner than one part cement, two and one half parts sand, and five parts gravel, having the same minimum compressive strength.

#### 2.2.1.2 Precast Thrust Blocks

Provide precast concrete thrust blocks.

#### 2.2.1.3 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 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.

#### 2.2.3 Sleeve-Type Mechanical Couplings

Use 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, the middle ring is cast-iron or steel; and the follower rings are malleable or ductile iron. For steel piping, the middle ring is steel and the follower rings are steel or malleable iron. Cast iron, ASTM A48/A48M not less than Class 25. Malleable and ductile iron are to meet the requirements of ASTM A47/A47M and ASTM A536, respectively. Steel is to have a strength not less than that of the pipe. 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 nuts, ASTM A563, Grade A; or round-head square-neck type bolts, ASME B18.5.2.1M and ASME B18.5.2.2M with hex nuts, ASME B18.2.2. Provide 5/8 inch diameter bolts; minimum number of bolts for each coupling is 4 for 4 inch pipe, 3 for 3 inch pipe, and 5 for 6 inch pipe. 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.

#### 2.2.4 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.

#### 2.2.5 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.

#### 2.2.6 Water Service Line Appurtenances

##### 2.2.6.1 Corporation Stops

Ground key type; lead-free bronze, ASTM B61 or ASTM B62; compatible with the working pressure of the system and solder-joint, or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.

##### 2.2.6.2 Curb or Service Stops

Ground key, round way, inverted key type; made of lead-free bronze, ASTM B61 or ASTM B62; and compatible with the working pressure of the system. Provide compatible ends for connection to the service piping. Cast an arrow into body of the curb or service stop indicating direction of flow.

##### 2.2.6.3 Service Clamps

Provide single or double flattened strap type service clamps used for repairing damaged cast-iron, steel or PVC pipe with a pressure rating not less than that of the pipe being repaired. Provide clamps with a galvanized malleable-iron body with cadmium plated straps and nuts and a rubber gasket cemented to the body.

##### 2.2.6.4 Goosenecks

Manufacture goosenecks from Type K copper tubing; provide joint ends for goosenecks compatible with connecting to corporation stop and service line. Where multiple gooseneck connections are required for an individual service, connect goosenecks to the service line through a compatible lead-free brass or bronze branch connection; the total clear area of the branches to be at least equal to the clear area of the service line.

##### 2.2.6.5 Curb Boxes

Provide a curb box for each curb or service stop manufactured from cast iron, size capable of containing the stop where it is used. Provide a round head. Cast the word "WATER" on the lid. Factory coat the box with a heavy coat of bituminous paint.

### 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. Do not install copper tubing in the same trench with ferrous piping materials. 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 2 1/2 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, *except as otherwise specified, tap concrete pipe in accordance with AWWA M9 for tapping concrete pressure pipe.*

#### 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.

- a. Normal Conditions: Lay water piping at least 10 feet horizontally from sewer or sewer manhole whenever possible. Measure the distance from outside edge to outside edge of pipe or outside edge of manhole. When local conditions prevent horizontal separation install water piping in a separate trench with the bottom of the water piping at least 18 inches above the top of the sewer piping.
- b. Unusual Conditions: When local conditions prevent vertical separation, construct sewer piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. When local conditions prevent vertical separation, test the sewer manhole in place to ensure watertight construction.

#### 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. Lay water lines which cross sewer force mains and inverted siphons at least 2 feet above these sewer lines; when joints in the sewer line are closer than 3 feet horizontally from the water line relay the sewer line to ensure no joint closer than 3 feet.

- a. Normal Conditions: Provide a separation of at least 18 inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.
- b. Unusual Conditions: When local conditions prevent a vertical separation described above, construct sewer piping passing over or under water piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to



backfilling. Construct sewer crossing with a minimum 20 feet length of the AWWA compliant ductile iron water piping, centered at the point of the crossing so that joints are equidistant and as far as possible from the water piping. Protect water piping passing under sewer piping by providing a vertical separation of at least 18 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on or damage to the water piping.

#### 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.

#### 3.2.1.1.9 Flanged Pipe

Only install flanged pipe aboveground or with the flanges in valve pits.

#### 3.2.1.2 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.

### 3.2.1.3 Plastic Service Piping

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the applicable requirements of ASTM D2774 and ASTM D2855, unless otherwise specified. Handle solvent cements used to join plastic piping in accordance with ASTM F402.

#### 3.2.1.3.1 Jointing

Make solvent-cemented joints for PVC piping using the solvent cement previously specified for this material; assemble joints in accordance with ASTM D2855. Make plastic pipe joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

#### 3.2.1.3.2 Plastic Pipe Connections to Appurtenances

Connect plastic service lines to corporation stops and gate valves in accordance with the recommendations of the plastic pipe manufacturer.

#### 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 water service lines 2 inch size to the main with a rigid connection or a corporation stop and gooseneck and install a gate valve on service line below the frostline as indicated. Connect 4 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 concrete water mains in accordance with the recommendations of AWWA M9, "Tapping Concrete Pressure Pipe." 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

Disinfection of systems supplying non-potable water is not required.

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 the manufacturer's instructions [NFPA 24](#) where indicated. For metal harness use tie rods and clamps as shown in [NFPA 24](#). 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 and PVC-O 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.

#### 3.2.5.2 Check Valves

Install check valves in accordance with the applicable requirements of [AWWA C600](#) for valve-and-fitting installation, except as otherwise indicated. Make and assemble joints to check valves as specified for making and assembling the same type joints between pipe and fittings.

#### 3.2.5.3 Air Release, Air/Vacuum, and Combination Air Valves

Install pressure vacuum assemblies of type, size, and capacity indicated. Include valves and test cocks. Install according to the requirements of plumbing and health department and authorities having jurisdiction. Do not install pressure vacuum breaker assemblies in vault or other space

subject to flooding.

### 3.2.6 Blowoff Valve Assemblies

Install blowoff valve assemblies as indicated on the drawings or in accordance with the manufactures recommendations. Install discharge fitting on the end of riser pipe to direct the flow of water so as to minimize damage to surrounding areas.

### 3.2.7 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 PVC and PVC0 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 water service lines in accordance with requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at copper pipe joints, copper tubing joints (soldered, compression type, brazed), plastic 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 Hydrostatic Sewer Test

The hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600.

#### 3.3.1.3 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.

For PE perform leak testing in accordance with [ASTM F2164](#).

#### 3.3.1.4 Bacteriological Testing

Perform bacteriological tests in accordance with [AWWA C651](#) Option A or Option B. 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](#).

#### 3.3.1.5 Backflow Preventer Tests

After installation conduct [Backflow Preventer Tests](#) and provide test reports verifying that the installation meets the [FCCCHR Manual](#) Standards.

#### 3.3.1.6 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](#)

#### 3.3.1.7 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 --

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SECTION 33 11 23

NATURAL GAS AND LIQUID PETROLEUM PIPING

PART 1 GENERAL

1.1 SUMMARY

This specification section applies to gas service line piping between the new connection to the gas distribution main and the outlet of the meter regulator station installed in the mechanical yard.

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 B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.3	(2000/2019) Rotary-Type Gas Displacement Meters
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

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Butt welding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems

	Up to 125 psi, (Sizes NPS 1/2 - NPS 2)
ASME B16.38	(2012; R 2017) Large Metallic Valves for Gas Distribution Manually Operated, NPS 2 1/2 (DN 65) to NPS 12 (DN 300), 125 psig 8.6 bar) Maximum
ASME B16.39	(2014) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.40	(2019) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII D1	(2017) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193/A193M	(2017) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2018) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM D2513	(2014; E 20142018a) Thermoplastic Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2683	(2014) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM F1802	(2015) Standard Test Method for Performance Testing of Excess Flow Valves
ASTM F2138	(2012; R 2017) Standard Specification for Excess Flow Valves for Natural Gas Service



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

MSS SP-115	(2017) Excess Flow Valves, NPS 11/4 and Smaller, for Fuel Gas Service
MSS SP-142	(2012) Excess Flow Valves for Fuel Gas Service, NPS 1 1/2 through 12
MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2018) National Fuel Gas Code
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U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders
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U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
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1.3 RELATED REQUIREMENTS

Section 23 11 25 FACILITY GAS PIPING for piping downstream of the meter/regulator assembly.

1.4 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-03 Product Data

PE Pipe and Fittings; G

Valve Box

Service Regulators; G

Excess Flow Valve; G

Valves; G

Warning and Identification Tape; G

Risers; G

Transition Fittings; G

Gas meter; G

#### SD-06 Test Reports

PE Fusion Welding Inspection; G

Pressure Tests; G

#### SD-07 Certificates

Welder's Procedures and Qualifications; G

PE Welder's Procedures and Qualifications; G

Welder's Identification Symbols; G

#### SD-08 Manufacturer's Instructions

PE Pipe and Fittings; G

Submit manufacturer's installation instructions and  
manufacturer's visual joint appearance chart.

### 1.5 QUALITY ASSURANCE

#### 1.5.1 Welder's Procedures and Qualifications

Comply with **ASME B31.8**. The steel welder shall have a copy of a certified **ASME B31.8** qualification test report. The PE welder shall have a certificate from a PE pipe manufacturer's sponsored training course. Contractor shall also conduct a qualification test. Submit each **welder's identification symbols**, assigned number, or letter, used to identify work of the welder. Affix symbols immediately upon completion of welds. Welders making defective welds after passing a qualification test shall be given a requalification test and, upon failing to pass this test, shall not be permitted to work this contract.

#### 1.5.2 PE Welder's Procedures and Qualifications

Prior to installation, Contractor shall have supervising and installing personnel trained by a PE pipe manufacturer's sponsored course of not less than one week duration, or present proof satisfactory to the Contracting Officer that personnel are currently working in the installation of PE gas distribution lines.

#### 1.5.3 Safety Standards

**49 CFR 192.**

### 1.6 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe ends during transportation or storage to minimize dirt and moisture entry. Do not subject to abrasion or concentrated external

loads. Discard PE pipe sections and fittings that have been damaged.

## PART 2 PRODUCTS

### 2.1 MATERIALS AND EQUIPMENT

Conform to 49 CFR 192 and with requirements specified herein. Supply piping to appliances or equipment shall be at least as large as the inlets thereof.

### 2.2 PIPE AND FITTINGS

#### 2.2.1 Aboveground and Within Buildings and Vaults

- a. Pipe: Black steel in accordance with ASTM A53/A53M, Schedule 40, square ends for socket welding for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.
- b. Threaded Fittings: ASME B16.3, black malleable iron ASTM A53/A53M, Schedule 80 threaded nipples where threading is used. Threaded fittings should only be used at locations where disassembly of pipe components is required for maintenance.
- c. Socket-Welding Fittings: ASME B16.11, forged steel.
- d. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.
- e. Unions: ASME B16.39, black malleable iron.
- f. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1. Flange faces shall have integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

#### 2.2.2 Underground Polyethylene (PE)

PE pipe and fittings are as follows:

- a. Pipe: ASTM D2513, 100 psig working pressure, Standard Dimension Ratio (SDR), the ratio of pipe diameter to wall thickness, 11.5 maximum.
- b. Socket Fittings: ASTM D2683.
- c. Butt-Fusion Fittings: ASTM D2513, molded.

#### 2.2.3 Risers

Manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide remote bolt-on or bracket.

#### 2.2.4 Transition Fittings

- a. Steel to Plastic (PE): As specified for "riser" except designed for steel-to-plastic with tapping tee or sleeve. Coat or wrap exposed steel pipe with heavy plastic coating.

- b. Plastic to Plastic: Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support, O-ring seals, and rated for 150 psig gas service.

## 2.3 SHUTOFF VALVES, BELOW GROUND

### 2.3.1 PE Ball or Plug Valves

ASME B16.40 and ASTM D2513, Class C materials (PE 2306 or PE 3406), strength rating of Class 4 location with class factor of 0.20, and SDR matching PE pipe dimensions and working pressure.

## 2.4 VALVES, ABOVEGROUND

Provide lockable valves where indicated.

### 2.4.1 Shutoff Valves, Sizes Larger Than 2 Inches

Steel body ball valve with flanged ends in accordance with ASME B16.38. Provide PTFE seats.

Steel body plug valve in accordance with ASME B16.38, nonlubricated, wedge-mechanism or tapered lift plug, and flanged ends.

### 2.4.2 Shutoff Valves, Sizes 2 Inches and Smaller

Bronze body ball valve in accordance with ASME B16.33, full port pattern, reinforced PTFE seals, threaded ends, and PTFE seat.

### 2.4.3 Service Regulators

- a. Provide steel bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide service regulators conforming to AGA ANSI B109.4 CGA-6.18-M95 with full capacity internal relief and overpressure shutoff. Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.
- b. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas flow rate at the regulator inlet pressure. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self-contained service regulator, and pipe not exceeding exceed 2 inch size.

### 2.4.4 Excess Flow Valve

All new modified gas service lines shall contain an "Excess Flow Valve" (EFV) in compliance with 49 CFR 192.381. An EFV interrupts the flow of gas if the service line is damaged by excavation activity or gas service riser components suffer damage. EFVs shall be installed when operating conditions are compatible with readily available valves. EFVs shall meet or exceed 49 CFR 192.381, MSS SP-115 or MSS SP-142; ASTM F1802 and ASTM F2138 requirements. Each valve capsule shall be lot coded with date and model number traceable back to all component parts from the

manufacturer.

## 2.5 GAS METER

Provide diaphragm-type meter conforming to AGA ANSI B109.2, for flow rates 500 cfh and above or rotary-type displacement meter conforming to AGA ANSI B109.3 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 with frost 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 shall be 30,000,000 cycles.

### 2.5.1 Utility Monitoring and Control System (UMCS) / Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS / EMCS for data gathering in units of cubic feet. Provide meters that do not require power to function and deliver data. Output signal shall be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor.

## 2.6 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.

## 2.7 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

Provide detectable aluminum-foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inch minimum width, color-coded yellow for natural gas, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED GAS PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

## 2.8 HANGERS AND SUPPORTS

MSS SP-58, as required by MSS SP-69.

## 2.9 WELDING FILLER METAL

ASME B31.8.

## 2.10 PIPE-THREAD TAPE

Antiseize and sealant tape of polytetrafluoroethylene (PTFE).

## 2.11 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; [ASTM A193/A193M](#), Grade B8M or B8MA, Type 316, for bolts; and [ASTM A194/A194M](#), Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts shall conform with [ASME B18.2.1](#) and [ASME B18.2.2](#) with coarse threads conforming to [ASME B1.1](#), with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs shall extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts shall have American Standard regular square or heavy hexagon heads; nuts shall be American Standard heavy semifinished hexagonal.

## 2.12 GASKETS

Fluorinated elastomer, compatible with flange faces.

## 2.13 IDENTIFICATION FOR ABOVEGROUND PIPING

[MIL-STD-101](#) for legends and type and size of characters. For pipes [3/4 inch](#) od and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than [3/4 inch](#) od, provide brass identification tags [1 1/2 inches](#) in diameter with legends in depressed black-filled characters.

# PART 3 EXECUTION

## 3.1 INSTALLATION

Install distribution piping in accordance with [ASME B31.8](#) and [49 CFR 192](#). Provide connection of service line to existing distribution main.

### 3.1.1 Excavating and Backfilling

Perform excavating and backfilling of pipe trenches as specified in Section [31 00 00 EARTHWORK](#). Place pipe directly in trench bottom and cover with minimum [3 inches](#) of sand to top of pipe. If trench bottom is rocky, place pipe on a [3 inch](#) bed of sand and cover as above. Provide remaining backfilling. Coordinate provision of utility warning and identification tape with backfill operation. Bury utility warning and identification tape with printed side up at a depth of [12 inches](#) below the top surface of earth or the top surface of the subgrade under pavements.

### 3.1.2 Piping

Cut pipe to actual dimensions and assemble to prevent residual stress. Provide supply connections entering the buildings as indicated.

#### 3.1.2.1 Cleanliness

Clean inside of pipe and fittings before installation. Blow lines clear using [80 to 100 psig](#) clean dry compressed air. Rap steel lines sharply along entire pipe length before blowing clear. Cap or plug pipe ends to

maintain cleanliness throughout installation.

#### 3.1.2.2 Aboveground Steel Piping

Determine and establish measurements for piping at the job site and accurately cut pipe lengths accordingly. For 2 inch diameter and smaller, use socket-welded joints, use threaded joints only where connecting to valves or regulators, and use flanged joints where indicated.

- a. Threaded Joints: Where possible use pipe with factory-cut threads, otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Provide threads smooth, clean, and full-cut. Apply anti-seize paste or tape to male threads portion. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Use unions for connections to valves, meters, strainers, and regulators for which a means of disconnection is not otherwise provided.
- b. Welded Joints: Weld by the shielded metal-arc process, using covered electrodes and in accordance with procedures established and qualified in accordance with ASME B31.8.
- c. Flanged Joints: Use flanged joints for connecting welded joint pipe and fittings to valves to provide for disconnection. Install joints so that flange faces bear uniformly on gaskets. Engage bolts so that there is complete threading through the nuts and tighten so that bolts are uniformly stressed and equally torqued.
- d. Pipe Size Changes: Use reducing fittings for changes in pipe size. Size changes made with bushings will not be accepted.
- e. Painting: Paint new ferrous metal piping, including supports, in accordance with Section 09 90 00 PAINTS AND COATINGS. Do not apply paint until piping tests have been completed.
- f. Identification of Piping: Identify piping aboveground in accordance with MIL-STD-101, using adhesive-backed or snap-on plastic labels and arrows. In lieu of labels, identification tags may be used. Apply labels or tags to finished paint at intervals of not more than 50 feet. Provide two copies of the piping identification code framed under glass and install wheredirected.

#### 3.1.2.3 Buried Plastic Lines

Provide totally PE piping. Prior to installation, obtain printed instructions and technical assistance in proper installation techniques from pipe manufacturer. When joining new PE pipe to existing pipe line, use mechanical joints.

- a. Jointing Procedures: Use jointing procedures conforming to AGA XR0603 and 49 CFR 192 that have been qualified by test in accordance with 49 CFR 192.283 and proven to make satisfactory joints. Personnel make joints in plastic pipe shall be qualified in accordance with 49 CFR 192.285, under the submitted and approved procedure by making a satisfactory specimen joint that passes the required inspection and test. Joints in plastic pipe shall be inspected by a person qualified by 49 CFR 192.287 under the applicable procedure. Certificates that

qualify the applicable procedures, joining personnel, and inspectors shall be submitted and approved and shall be on file with the Contracting Officer prior to making these joints.

- b. PE Piping: Prior to installation, Contractor shall have supervising and installing personnel, certified in accordance with paragraph WELDER'S QUALIFICATIONS. Provide fusion-welded joints except where transitions have been specified. Use electrically heated tools, thermostatically controlled and equipped with temperature indication. (Where connection must be made to existing plastic pipe, contractor shall use a mechanical joint.
- c. Laying PE Pipe: Bury pipe 36 inches below finish grade. Lay in accordance with manufacturer's printed instructions.

#### 3.1.2.4 Connections to Existing Pipeline

When making connections to live gas mains, use pressure tight installation equipment operated by workmen trained and experienced in making hot taps. For connections to existing underground pipeline or service branch, use transition fittings for dissimilar materials.

#### 3.1.2.5 Wrapping

Where connection to existing steel line is made underground, tape wrap new steel transition fittings and exposed existing pipe having damaged coating. Clean pipe to bare metal. Initially stretch first layer of tape to conform to the surface while spirally half-lapping. Apply a second layer, half-lapped and spiraled as the first layer, but with spirals perpendicular to first wrapping. Use 10 mil minimum thick polyethylene tape. In lieu of tape wrap, heat shrinkable 10 mil minimum thick polyethylene sleeve may be used.

#### 3.1.3 Valves

Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide support for valves to resist operating torque applied to PE pipes.

##### 3.1.3.1 Stop Valve and Shutoff Valve

Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

##### 3.1.3.2 Excess Flow Valve

Install excess flow valve in very close proximity to the service line connection to the main. Protect excess flow valve and service tee connection with an oversized, 24-inch long protective Schedule 80 PVC pipe sleeve, with one end landing near tap and the other end in firm soil.

#### 3.1.4 Gas Service Installation

Installations shall be in accordance with 49 CFR 192 and ASME B31.8. Contractor shall submit and use only tested and approved work procedures. Contractor shall use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product shall be inspected by a person qualified to inspect joints made by the particular procedures used



to make joints.

#### 3.1.4.1 Service Line

Install service line, branch connection to the main, and riser in accordance with 49 CFR 192 and ASME B31.8. Provide a minimum of 18 inches cover or encase the service line so that it is protected. Install service line so that no undue stress is applied to the pipe, connection, or riser. Install approved riser and terminate with an approved isolation valve, EFV and automatic shutoff device. After laying of pipe and testing, backfill the trench in accordance with Section 31 00 00 EARTHWORK.

Where steel pipe is used as service line, install corrosion prevention coating and cathodic protect for the steel service line. Where connected to an existing cathodically protected steel pipe, ensure electrical continuity from the riser to the branch connection to the main. Install a dielectric fitting on the riser to prevent electrical continuity to the above ground piping.

Where plastic pipe is used as the service line, make joints in accordance with procedures qualified by test. Personnel joining plastic pipe shall be qualified by making a satisfactory specimen joint that passes the required inspection and test listed in 49 CFR 192.285. Inspection shall be made by inspectors qualified in evaluating joints made under the specific joining procedure, as required by 49 CFR 192.287.

#### 3.1.4.2 Service Regulator

Install service regulator in accordance with 49 CFR 192 and ASME B31.8 and this specification ensuring that the customer's piping is protected from over pressurization should the service regulator fail. A 3/8 inch tapped fitting equipped with a plug shall be provided on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. Route the regulator vent pipe through the mechanical courtyard wall to 6 inches above the wall. Terminate the regulator vent so that it is protected from precipitation and insect intrusion, so that it is not submerged during floods, and so that gas escaping will not create a hazard or enter the building through openings.

#### 3.1.4.3 Gas Meter

Install shutoff valve, meter set assembly, and service regulator on the service line outside the building in the mechanical courtyard, 18 inches above the finished courtyard floor. An insulating joint (dielectric connection) shall be installed on the inlet side of the meter set assembly and service regulator and shall be constructed to prevent flow of electrical current.

#### 3.1.5 Pipe Sleeves

Where piping penetrates concrete or masonry wall, floor or firewall, provide pipe sleeve poured or grouted in place. Make sleeve of steel or cast-iron pipe of such size to provide 1/4 inch or more annular clearance around pipe. Extend sleeve through wall or slab and terminate flush with both surfaces. Pack annular space with oakum, and caulk at ends with silicone construction sealant.

### 3.1.6 Piping Hangers and Supports

Selection, fabrication, and installation of piping hangers and supports shall conform with MSS SP-69 and MSS SP-58, unless otherwise indicated.

### 3.1.7 Final Connections

Make final connections to building distribution line at the meter exit using rigid pipe and fittings.

## 3.2 FIELD QUALITY CONTROL

### 3.2.1 Metal Welding Inspection

Inspect for compliance with ASME B31.8 and 49 CFR 192. Replace, repair, and then re-inspect defective welds.

### 3.2.2 PE Fusion Welding Inspection

Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect 100 percent of all joints and reinspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

### 3.2.3 Pressure Tests

Use test pressure of 1 1/2 times maximum working pressure, but in no case less than 60 psig. Do not test until every joint has set and cooled at least 8 hours at temperatures above 50 degrees F. Conduct testing before backfilling; however, place sufficient backfill material between fittings to hold pipe in place during tests. Test system gas tight in accordance with NFPA 54 or ASME B31.8. Use clean dry air or inert gas, such as nitrogen or carbon dioxide, for testing. Systems which may be contaminated by gas shall first be purged as specified. Make tests on entire system or on sections that can be isolated by valves. After pressurization, isolate entire piping system from sources of air during test period. Maintain test pressure for at least 8 hours between times of first and last reading of pressure and temperature. Take first reading at least one hour after test pressure has been applied. Do not take test readings during rapid weather changes. Provide temperature same as actual trench conditions. There shall be no reduction in the applied test pressure other than that due to a change in ambient temperature. Allow for ambient temperature change in accordance with the relationship  $PF + 12.02 = (P1 + 12.02) (T2 + 460) / T1 + 460$ , in which "T" and "PF" represent Fahrenheit temperature and gage pressure, respectively, subscripts "1" and "2" denote initial and final readings, and "PF" is the calculated final pressure. If "PF" exceeds the measured final pressure (final gage reading) by 1/2 psi or more, isolate sections of the piping system, retest each section individually, and apply a solution of warm soapy water to joints of each section for which a reduction in pressure occurs after allowing for ambient temperature change. Repair leaking joints and repeat test until no reduction in pressure occurs. In performing tests, use a test gage calibrated in one psi increments and readable to 1/2 psi.

#### 3.2.4 System Purging

After completing pressure tests, and before testing a gas contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clear completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures shall conform to [NFPA 54](#) and [ASME B31.8](#).

-CAUTION-
Failure to purge may result in explosion within line when air-to-gas is at correct mixture.

-- End of Section --

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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 WATER WORKS ASSOCIATION (AWWA)

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
AWWA C605	(2014) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVC0) Pressure Pipe 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 M9	(2008; Errata 2013) Manual: Concrete Pressure Pipe

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2012) 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 2014) Standard Specification for Ductile Iron Castings
ASTM C12	(2017) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C94/C94M	(2018) Standard Specification for Ready-Mixed Concrete
ASTM C150/C150M	(2018) Standard Specification for Portland Cement

ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C270	(2014a2019) Standard Specification for Mortar for Unit Masonry
ASTM C443	(2012; R 2017) 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 C923	(2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C969	(2019) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C972	(2000; R 2011) Compression-Recovery of Tape Sealant
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1644	(2006; R 2017) Standard Specification for Resilient Connectors Between Reinforced Concrete On-Site Wastewater Tanks and Pipes
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D624	(2000; R 2012) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D2321	(2018) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2412	(2011) 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	(2007; R 2013) 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) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F794	(2003; R 2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F949	(2015) 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	(N0v 2016) Scaffolds and Roope Descent Systems
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1.2 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. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor's License; G

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Precast Concrete Manholes

Frames, Covers, and Gratings

Gravity Pipe

SD-06 Test Reports

Infiltration Tests And Exfiltration Tests; G

Deflection Testing

SD-07 Certificates

Portland Cement

Pre-Installation Inspection Request; G

Post-Installation Inspection; G

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. Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. 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 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 PVC Gravity Sewer Piping

##### 2.2.1.1.1 PVC Gravity Pipe and Fittings

ASTM D3034, SDR 35, or 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.

##### 2.2.1.1.2 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 or V 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 air-entraining admixture conforming to ASTM C260/C260M with Type V cement. 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.

#### 2.2.6 Gaskets and Connectors

Provide gaskets for joints between manhole wastewater tanks sections conforming to ASTM C443. Resilient connectors for making joints between manhole wastewater tanks and pipes entering manhole are to conform to ASTM C1644, 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

Submit certification on the ability of frame and cover to carry the imposed live load. 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 with vent holes. Size are to be as indicated on the plans 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 as indicated conforming to 29 CFR 1910.27 with a plastic or rubber coating pressure-molded to the steel is to be used. Provide plastic coating conforming to ASTM D4101, copolymer polypropylene. Rubber is to conform to ASTM C443, except shore A durometer hardness is to be 70 plus or minus 5. 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, unless otherwise indicated.

###### 3.2.2.1.1 Sanitary Piping Installation Parallel with Water Line

###### 3.2.2.1.1.1 Normal Conditions

Install sanitary piping or manholes at least 10 feet horizontally from a water line whenever possible. Measure the distance from edge-to-edge.

###### 3.2.2.1.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of 10 feet, the sanitary piping or manhole may be laid closer to a water line provided that:

- a. The top (crown) of the sanitary piping is to be at least 18 inches below the bottom (invert) of the water main.
- b. Where this vertical separation cannot be obtained, construct the

sanitary piping with AWWA-approved ductile iron water pipe pressure and conduct a hydrostatic sewer test without leakage prior to backfilling.

- c. The sewer manhole is to be of watertight construction and tested in place.

#### 3.2.2.1.2 Installation of Sanitary Piping Crossing a Water Line

##### 3.2.2.1.2.1 Normal Conditions

Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 18 inches between the top of the sanitary piping and the bottom of the water line whenever possible.

##### 3.2.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

- a. Construct sanitary piping passing over or under water lines with AWWA-approved ductile iron water pressure piping and conduct a hydrostatic sewer test without leakage prior to backfilling.
- b. Protect sanitary piping passing over water lines by providing:
  - (1) A vertical separation of at least 18 inches between the bottom of the sanitary piping and the top of the water line.
  - (2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.
  - (3) That the length, minimum 20 feet, of the sanitary piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the water line.

##### 3.2.2.1.3 Sanitary Sewer Manholes

No water piping shall 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 or groove ends in the upgrade direction. Adjust spigots in bells and tongues in grooves to give a uniform space all around. Blocking or wedging between bells and spigots or tongues and grooves 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 Clay 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 C12](#) for pipe laying. Make joints with a compression joint material specified for clay pipe joints and assemble in accordance with the recommendations of the manufacturer of the pipe.

#### 3.2.3.2 Installation of Concrete Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the laying and joining requirements specified in the guide specifications for installation of pipe given in [AWWA M9](#), Chapter 14, "Guide Specifications for Installation of Pipe."

##### 3.2.3.2.1 Joints

Make joints with the gaskets specified for concrete pressure pipe joints, using an approved lubricant recommended by the pipe manufacturer. Assemble these joints in accordance with the joining requirements specified in the guide specifications for installation of pipe given in [AWWA M9](#), Chapter 14, "Guide Specifications for Installation of Pipe," and with the recommendations given for laying the pipe in [AWWA M9](#), Chapter 6, "Installation by Trenching or Tunneling -- Methods and Equipment."

##### 3.2.3.2.2 Pipe Anchorage

Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to [ASTM C94/C94M](#) having a minimum compressive strength of 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

#### 3.2.3.3 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.

#### 3.2.3.4 Installation of PVC Pressure Pipe

##### 3.2.3.4.1 Pipe Less Than 4 Inch Diameter

###### 3.2.3.4.1.1 Threaded Joints

Make by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together.

Tighten the joints with strap wrenches which will not damage the pipe and fittings. Tighten the joint no more than 2 threads past hand-tight.

#### 3.2.3.4.1.2 Push-On Joints

Bevel the ends of pipe for push-on joints to facilitate assembly. Mark pipe to indicate when the pipe is fully seated. Lubricate the gasket to prevent displacement. Exercise care to ensure that the gasket remains in proper position in the bell or coupling while making the joint.

#### 3.2.3.4.1.3 Solvent-Weld Joints

Comply with the manufacturer's instructions.

#### 3.2.3.4.2 Pipe 4 inch Diameter And Larger

Make push-on joints with AWWA C900 pipe with integral elastomeric gasket. 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 fittings, use cut spigot end of pipe off square, marked to match the manufacturer's insertion line and beveled to match factory supplied bevel. Use an approved 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. Assemble push-on joints for connection to fittings in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories and with the applicable requirements of AWWA C600 for joint assembly. Make mechanical-joints or flanged joints with the gaskets, glands, bolts, nuts, and internal stiffeners specified for this type joint and assemble in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories or with the applicable requirements of AWWA C600 for ductile iron joint assembly, and with the recommendations of Appendix A to AWWA C111/A21.11. Cut off spigot end of pipe for mechanical-joint or flanged joint connections and do not bevel.

#### 3.2.3.4.3 Pipe Anchorage

Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

#### 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.

### 3.2.7 Sewage Absorption Trench Construction

Grade trenches uniformly with no slope. Lay perforated pipe with the perforations downward. Comply with the chamber manufacturer's instructions.

### 3.2.8 Installations of Wye Branches

Install wye branches in an existing sewer using a method which does not damage the integrity of the existing sewer. Do not cut into piping for

connections except when approved by the Contracting Officer. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, support on a concrete cradle as directed by the Contracting Officer. Provide and install concrete required because of conditions resulting from faulty construction methods or negligence without any additional cost to the Government. Do not damage the existing sewer when installing wye branches in an existing sewer.

### 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 infiltration tests and exfiltration tests, negative air pressure tests 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 Infiltration Tests and Exfiltration Tests

###### 3.3.1.1.1.1 Precast Concrete Pipe Sewer Lines

Test leakage of precast concrete pipe in accordance with [ASTM C969](#). The allowable leakage limit is located in [ASTM C969](#). Make calculations in accordance with the Appendix to [ASTM C969](#).

##### 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.

#### 3.3.1.3 Dye Test

Perform a dye test from the projects sanitary sewer point of connection to the first downstream manhole on the next active sanitary sewer branch main. Use nontoxic non-staining sewer tracing dye. Test results are to be noted in the daily Construction Quality Control (CQC) Report as required in 01 45 00.00 10 Quality Control.

- a. Continue testing until it can be visually confirmed by way of the dye that the sewer connection is appropriate or until deficiencies are discovered.
- b. During the test, monitor the storm drainage system downstream from the project, either manholes or outfalls, for any sign of cross-connection.

#### 3.3.1.4 Smoke Test

Perform a smoke test on the relevant portion of the sewer system. Test

results are to be noted in the daily Construction Quality Control (CQC) as required in 01 45 00.00 10 Quality Control.

- a. Continue testing until it can be visually confirmed that the projects sanitary sewer point of connection has not been cross-connected to the storm drainage system.
- b. During the test, monitor the storm drainage system, either manholes or outfalls, for any sign of cross-connection.

### 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.

#### 3.3.3.1 Pre-Installation Inspection

Prior to connecting the new service, perform pre-installation inspection after trenching and layout is complete. Submit [pre-installation inspection request](#) for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the pre-installation inspection.

#### 3.3.3.2 Post-Installation Inspection

Perform a post-installation inspection after connection has been made and before the connection is buried. Submit [post-installation inspection request](#) for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the post-connection inspection. During the post-installation inspection, the Contractor will be responsible for performing a dye test or smoke test.

-- End of Section --

SECTION 33 40 00

STORM DRAINAGE 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 M 294 (2017) Standard Specification for  
Corrugated Polyethylene Pipe, 300- to  
1500-mm (12- to 60-in.) Diameter

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M (2003; R 2012) 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 2014) Standard Specification for  
Ductile Iron Castings

ASTM A929/A929M (2018) Standard Specification for Steel  
Sheet, Metallic-Coated by the Hot-Dip  
Process for Corrugated Steel Pipe

ASTM B26/B26M (2014; E 2015) 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 (2017) Standard Specification for Concrete  
Building Brick

ASTM C62 (2017) Standard Specification for Building  
Brick (Solid Masonry Units Made from Clay  
or Shale)

ASTM C139 (2017) Standard Specification for Concrete  
Masonry Units for Construction of Catch  
Basins and Manholes

ASTM C231/C231M (2017a) Standard Test Method for Air  
Content of Freshly Mixed Concrete by the  
Pressure Method

ASTM C270	(2014a2019) Standard Specification for Mortar for Unit Masonry
ASTM C425	(2004; R 2013) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2012; R 2017) 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 C877	(2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1433	(2016b) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM D1056	(2014) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1171	(2016; E 2016) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking Outdoors (Triangular Specimens)
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft <sup>3</sup> ) (2700 kN-m/m <sup>3</sup> )
ASTM D1751	(2004; E 2013; R 2013) 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 D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2321	(2018) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D3212	(2007; R 2013) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F714	(2013) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F894	(2013/2019) Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe

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

### SD-04 Samples

Pipe for Culverts and Storm Drains

### SD-07 Certificates

Resin Certification

Oil Resistant Gasket

Hydrostatic Test on Watertight Joints

Determination of Density

Frame and Cover for Gratings

Post-Installation Inspection Report

### SD-08 Manufacturer's Instructions

Placing Pipe

### SD-11 Closeout Submittals

Lid Verification Report; G

### 1.3 DELIVERY, STORAGE, AND HANDLING

#### 1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected 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. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

#### 1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

## PART 2 PRODUCTS

### 2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

#### 2.1.1 Poly Vinyl Chloride (PVC) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, prior to installation of the pipe.

#### 2.1.2 Polyethylene (PE) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PE used to manufacture the pipe, prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350.

##### 2.1.2.1 Smooth Wall PE Pipe

ASTM F714, maximum DR of 21 for pipes 3 to 24 inches in diameter and maximum DR of 26 for pipes 26 to 48 inches in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

##### 2.1.2.2 Profile Wall PE Pipe

ASTM F894, RSC 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 334433C. Pipe walls shall have the following properties:

Nominal Size (inch)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in)	
		Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	7.81	0.202	0.165
42	8.08	0.277	0.227
48	8.82	0.338	0.277

## 2.2 DRAINAGE STRUCTURES

### 2.2.1 Flared End Sections

Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of [ASTM A929/A929M](#).

### 2.2.2 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to [ASTM C1433](#).

## 2.3 MISCELLANEOUS MATERIALS

### 2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 4,000 [psi](#) concrete under Section [03 30 00](#) CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, 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](#). Air content shall be determined in accordance with [ASTM C231/C231M](#). The concrete covering over steel reinforcing shall not be less than [1 inch](#) thick for covers and not less than [1-1/2 inches](#) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least [3 inches](#) between steel and ground. Expansion-joint filler material shall conform to [ASTM D1751](#), or [ASTM D1752](#), or shall be resin-impregnated fiberboard conforming to the physical requirements of [ASTM D1752](#).

### 2.3.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to [ASTM C270](#), Type M, except

that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

#### 2.3.3 Precast Concrete Segmental Blocks

Precast concrete segmental block shall conform 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.

#### 2.3.4 Brick

Brick shall conform to [ASTM C62](#), Grade SW; [ASTM C55](#), Grade S-I or S-II; or [ASTM C32](#), Grade MS. Mortar for jointing and plastering shall consist 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. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with [1/2 inch](#) of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

#### 2.3.5 Precast Reinforced Concrete Manholes

Conform to [ASTM C478](#). Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

#### 2.3.6 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be 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.O-T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

#### 2.3.7 Joints

##### 2.3.7.1 Flexible Watertight Joints

- a. Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to [ASTM C990](#), and rubber-type gaskets shall conform to [ASTM C443](#). Factory-fabricated resilient joint materials shall conform to [ASTM C425](#). Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are



permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches.

- b. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

#### 2.3.7.2 External Sealing Bands

Requirements for external sealing bands shall conform to ASTM C877.

#### 2.3.7.3 Flexible Watertight, Gasketed Joints

- a. Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 7 inches wide and approximately 3/8 inch thick, meeting the requirements of ASTM D1056, Type 2 A1 or B3, and shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171. Rubber O-ring gaskets shall be 13/16 inch in diameter for pipe diameters of 36 inches or smaller and 7/8 inch in diameter for larger pipe having 1/2 inch deep end corrugation. Rubber O-ring gaskets shall be 1-3/8 inches in diameter for pipe having 1 inch deep end corrugations. O-rings shall meet the requirements of ASTM C990 or ASTM C443. Preformed flexible joint sealants shall conform to ASTM C990, Type B.
- b. Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of band, and the size of angles, bolts, rods and lugs as indicated or where not indicated as specified in the applicable standards or specifications for the pipe. Exterior rivet heads in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded. Watertight joints shall be tested and shall meet the test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

#### 2.3.7.4 PVC Plastic Pipes

Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

#### 2.3.7.5 Smooth Wall PE Plastic Pipe

Pipe shall be joined using butt fusion method as recommended by the pipe manufacturer.

#### 2.3.7.6 Corrugated PE Plastic Pipe

Pipe joints shall be soil, silt, and water tight and shall conform to the requirements in AASHTO M 294. Water tight joints shall be made using a PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477.

#### 2.3.7.7 Profile Wall PE Plastic Pipe

Joints shall be gasketed or thermal weld type with integral bell in

accordance with ASTM F894.

## 2.4 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds 12 feet. These ladders shall be not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers shall be a minimum 3/8 inch thick and 2-1/2 inches wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M.

## 2.5 EROSION CONTROL RIP RAP

Provide non-erodible rock not exceeding 15 inches in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of 8 inches or as indicated.

# PART 3 EXECUTION

## 3.1 INSTALLATION OF PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

### 3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheet piling and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

### 3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe 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. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be 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, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheet piling, water removal, or other specified requirements, such removal and replacement shall be performed at no

additional cost to the Government.

### 3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

#### 3.2.1 Plastic Pipe

Bedding for PVC, PE, SRPE and PP pipe shall meet the requirements of ASTM D2321. Use Class IB or II material for bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

### 3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Corrugated Steel and Aluminum	5
Concrete-Lined Corrugated Steel	3
Plastic (PVC, PE, SRPE, and PP)	5

Note post installation requirements of paragraph DEFLECTION TESTING in PART 3 of this specification for all pipe products including deflection testing requirements for flexible pipe.

#### 3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron and Cast-Iron Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

### 3.4 JOINTING

### 3.5 DRAINAGE STRUCTURES

#### 3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal;

complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

### 3.5.2 Walls and Headwalls

Construction shall be as indicated.

## 3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet vertically and shall be installed to provide at least 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

## 3.7 BACKFILLING

### 3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of concrete pipe or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 12 inches. Tests for density shall be made 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. Untreated sheeting shall not be left in place beneath structures or pavements.

### 3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches in compacted depth, and shall be compacted 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 shall 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, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 12 inches. Use select granular material for this entire region of backfill for flexible pipe installations.

### 3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

### 3.7.4 Compaction

#### 3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

#### 3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

- a. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.
- b. Under nontraffic areas, density shall be not less than that of the surrounding material.

### 3.8 FIELD PAINTING

#### 3.8.1 Cast-Iron Covers, Frames, Gratings, And Steps

After installation, clean cast-iron, not buried in masonry or concrete, of mortar, rust, grease, dirt, and other deleterious materials to bare metal and apply a coat of bituminous paint.

#### 3.8.2 Steel Covers And Frames Or Concrete Frames

After installation, clean steel or concrete, not buried in masonry or concrete, of mortar, dirt, grease, and other deleterious materials to bare metal. Painting must conform to Section 09 90 00 PAINTS AND COATINGS. Do not paint surfaces subject to abrasion.

### 3.9 FIELD QUALITY CONTROL

#### 3.9.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

### 3.9.1.1 HYDROSTATIC TEST ON WATERTIGHT JOINTS

#### 3.9.1.1.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. 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. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to ASTM C990 or ASTM C443. Test requirements for joints in clay pipe shall conform to ASTM C425. Test requirements for joints in PVC, PE, and PP plastic pipe shall conform to ASTM D3212.

#### 3.9.1.2 Determination of Density

Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

#### 3.9.1.3 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 shall not exceed limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Use a laser profiler or mandrel to determine if allowable deflection has been exceeded.

##### 3.9.1.3.1 Laser Profiler

Inspect pipe interior with laser profiling equipment. Utilize low barrel distortion video equipment for pipe sizes 48 inches or less. Use a camera with suitable lighting to allow a clear picture of the entire periphery of the pipe interior. Center the camera in the pipe both vertically and horizontally. The camera must be able to pan and tilt to a 90 degree angle with the axis of the pipe rotating 360 degrees. Use equipment to move the camera through the pipe that will not obstruct the camera's view or interfere with proper documentation of the pipe's condition. The video image shall be clear, focused, and relatively free from roll static or

other image distortion qualities that would prevent the reviewer from evaluating the condition of the pipe. For initial post installation inspections for pipe sizes larger than 48 inches, a visual inspection shall be completed of the pipe interior.

#### 3.9.1.3.2 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 Concrete-Lined Corrugated Steel and Ductile Iron Culvert. The Government will verify the outside diameter (OD) of the Contractor provided mandrel through the use of Contractor provided proving rings.

#### 3.9.2 Inspection

##### 3.9.2.1 Post-Installation Inspection

Visually inspect each segment of concrete 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.

##### 3.9.2.1.1 Concrete

Cracks with a width greater than 0.01 inches. An engineer must evaluate all pipes with cracks with a width greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required.

##### 3.9.2.1.2 Flexible Pipe

Check each flexible pipe (PE, PVC, PP, Corrugated Steel And Aluminum) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

##### 3.9.2.1.3 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.).

##### 3.9.2.2 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.

### 3.9.3 Repair Of Defects

#### 3.9.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

#### 3.9.3.2 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.

#### 3.9.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

##### 3.9.3.3.1 Concrete

Replace pipes having cracks with a width greater than 0.1 inches.

##### 3.9.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

### 3.10 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

### 3.11 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 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 B800 (2005; R 2011) Standard Specification for  
8000 Series Aluminum Alloy Wire for  
Electrical Purposes-Annealed and  
Intermediate Tempers

ASTM B801 (2018) Standard Specification for  
Concentric-Lay-Stranded Conductors of 8000  
Series Aluminum Alloy for Subsequent  
Covering or Insulation

ASTM C309 (2011) 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 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM F512	(2012; R 2017) Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation
ASTM F2160	(2016) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

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	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA C119.4	(2011) Electric Connectors - Connectors for Use Between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93 Degrees C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100 Degrees C
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 7	(2016) Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
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SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity
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TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
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U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction
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UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 94	(2013; Reprint Sep 2017) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 510	(2017) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber

Insulating Tape

- UL 514B (2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
- UL 651 (2011; Reprint Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
- UL 854 (2004; Reprint Nov 2014) Standard for Service-Entrance Cables
- UL 1242 (2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel

1.2 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.
- c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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-02 Shop Drawings

Aluminum conductors; G

Submit modified drawings and engineering calculations associated with design changes required for use of aluminum conductors.

Precast underground structures; G

SD-03 Product Data

Precast concrete structures

Sealing Material

Pulling-In Irons

Handhole frames and covers; G

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators)

SD-06 Test Reports

Field Acceptance Checks and Tests

SD-07 Certificates

Directional Boring Certificate of Conformance

#### 1.4 QUALITY ASSURANCE

##### 1.4.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

- a. Material description (i.e., f'c and Fy)
- 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

##### 1.4.2 Directional Boring Certificate of Conformance

Provide certification of compliance with the registered Professional Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor derating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

##### 1.4.3 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.

##### 1.4.4 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. 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.

#### 1.4.4.1 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 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 Intermediate Metal Conduit

UL 1242.

##### 2.1.2.1 Intermediate Metal 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.

##### 2.1.3 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-40.

##### 2.1.4 Plastic Duct for Concrete Encasement

Provide Type EB-20 per UL 651, ASTM F512, and NEMA TC 6 & 8.

##### 2.1.5 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smoothwall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

##### 2.1.6 Innerduct

Provide corrugated polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts, with pullwire IAW applicable TIAs or local base policy. Size

as indicated.

#### 2.1.7 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

#### 2.1.8 Fittings

##### 2.1.8.1 Metal Fittings

UL 514B.

##### 2.1.8.2 PVC Conduit Fittings

UL 514B, UL 651.

##### 2.1.8.3 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, or in accordance with NEMA WC 70. Wires and cables manufactured more than 12 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. Conductors No. 6 AWG and smaller must be copper. Conductors No. 4 AWG and larger may be either copper or aluminum, at the Contractor's option. Do not substitute aluminum for copper if the equivalent aluminum conductor size would exceed 500 kcmil. When the Contractor chooses to use aluminum for conductors No. 4 AWG and larger, the Contractor must: increase the conductor size to have the same ampacity as the copper size indicated; increase the conduit and pull box sizes to accommodate the larger size aluminum conductors in accordance with NFPA 70; ensure that the pulling tension rating of the aluminum conductor is sufficient; relocate equipment, modify equipment terminations, resize equipment, and resolve to the satisfaction of the Contracting Officer problems that are direct results of the use of aluminum conductors in lieu of 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. Aluminum conductors must be Type AA-8000 aluminum conductors complying with

ASTM B800 and ASTM B801, and must be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted.

### 2.2.3 Jackets

Multiconductor cables must have an overall PVC outer jacket.

### 2.2.4 In Duct

Cables must be single-conductor cable.

### 2.2.5 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, or approved equal, in each manhole, 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.

Conductors must be color coded. 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. Control circuit terminations must be properly identified. 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 must be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems must be 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
- c. 120/240 volt, single phase: Black and red
- d. On three-phase, four-wire delta system, high leg must be orange, as required by NFPA 70.



## 2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Must 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](#).
- b. For use with aluminum conductors: [UL 486A-486B](#). For connecting aluminum to copper, connectors must be the circumferentially compressed, metallurgically bonded type.

## 2.4 LOW VOLTAGE SPLICES

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

### 2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

### 2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

## 2.5 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section [33 82 00](#) TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

## 2.6 TAPE

### 2.6.1 Insulating Tape

[UL 510](#), plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

### 2.6.2 Buried Warning and Identification Tape

Provide detectable tape.

### 2.6.3 Fireproofing Tape

Provide tape composed of a flexible, conformable, unsupported intumescent elastomer. Tape must be not less than [.030 inch](#) thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

## 2.7 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

## 2.8 GROUNDING AND BONDING

### 2.8.1 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 for rods 20 feet or longer.

### 2.8.2 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.

## 2.9 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.

## 2.10 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types 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 near the corners of structures 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.

### 2.10.1 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

#### 2.10.1.1 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 may be precast to the design and details indicated for cast-in-place construction, 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.

#### 2.10.1.2 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 ( $\phi$ ) = 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.

#### 2.10.1.3 Construction

Structure top, bottom, and wall must be of a uniform thickness of 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.

#### 2.10.1.4 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.

#### 2.10.2 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Steel covers must be rolled-steel floor plate having an approved antislip surface. Hinges must be of wrought steel, 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.

#### 2.10.3 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 and this rating must not exceed the design load of the box.

### 2.11 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms must be zinc-coated after fabrication.

#### 2.11.1 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, 48 inches long (minimum) in manholes. Slots for mounting cable rack arms must be spaced at 8 inch intervals.

#### 2.11.2 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 12 inches and a maximum of 12 inches.

### 2.11.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

## 2.12 CABLE TAGS IN MANHOLES AND HANDHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote 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.

### 2.12.1 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 must have a minimum loop tensile strength of 175 pounds. The cable tags must have 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.

## 2.13 LOW VOLTAGE ABOVE GROUND TERMINATION PEDESTAL

Provide copolymer polypropylene, low voltage above ground termination pedestal manufactured through an injection molding process. Pedestals must resist fertilizers, salt air environments and ultra-violet radiation. Pedestal top must be imprinted with a "WARNING" and "ELECTRIC" identification. Pedestal must contain four lay-in six port connectors. Connectors must be NEMA C119.4, Class "A", dual rated for aluminum or copper, and capable of terminating conductors ranging from 10 AWG to 500 kcmil. Protect each connector with a clear, hard lexan (plastic) cover. Pedestal must be provided with rust-free material and stainless steel hardware. Pedestal must be lockable.

## 2.14 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

## 2.15 SOURCE QUALITY CONTROL

# 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 and RUS Bull 1751F-644.

### 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 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or 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. Steel and iron must be formed 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. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

#### 3.3.1 Cast-In-Place Concrete Structures

Provide concrete block.

#### 3.3.2 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.

#### 3.3.3 [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 the irons must be a minimum of [6 inches](#) from the edge of the sump, and in the walls the irons must be located 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. Irons must be hot-dipped galvanized after fabrication.

#### 3.3.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 3 feet apart and provide each manhole wall with a minimum of two racks. Space racks in signal manholes 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 must be 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;" channel insert must be 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.

#### 3.3.5 Field Painting

Cast-iron frames and covers not buried in concrete or masonry must be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

### 3.4 UNDERGROUND CONDUIT AND DUCT SYSTEMS

#### 3.4.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor above medium-voltage distribution duct banks. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grounding conductor into manholes with the duct bank (sleeving is not required). 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. Provide ducts with end bells whenever duct lines terminate in structures.

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 36 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: 30 degrees.

#### 3.4.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.

#### 3.4.3 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.

#### 3.4.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit must be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers. Hydraulic jet method must not be used.

#### 3.4.5 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.

#### 3.4.6 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided 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.

#### 3.4.7 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide warning tape.

##### 3.4.7.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement must extend at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 24 inches below finished grade.

##### 3.4.7.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 48 inches in pavement-covered or non-pavement-covered areas. For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement-covered or non-pavement-covered areas.

#### 3.4.8 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 18 inches below finished grade, except under roads and pavement, 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 must 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 to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide warning tape.

#### 3.4.8.1 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. Cut steel and extend into the duct bank envelope. 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.

#### 3.4.8.2 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

#### 3.4.8.3 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. Remove existing cables which constitute interference with the work. Abandon in place those no longer used ducts and cables which do not interfere with the work.

#### 3.4.8.4 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.

#### 3.4.8.5 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.

#### 3.4.9 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

### 3.5 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 tape or wire shield 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.

### 3.5.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

## 3.6 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.

### 3.6.1 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.

## 3.7 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

## 3.8 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.

### 3.8.1 Terminating Aluminum Conductors

- a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors and use UL-listed solid aluminum connectors for connecting aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose.
- b. Terminate aluminum conductors to copper bus either by: (1) in line

splicing a copper pigtail to the aluminum conductor (copper pigtail must have a ampacity at least that of the aluminum conductor); or (2) using a circumferential compression type, aluminum bodied terminal lug UL listed for AL/CU and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers must be cadmium-plated hardened steel. Install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficient to flatten Belleville and leave in that position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

- c. Terminate aluminum conductors to aluminum bus by using all-aluminum nuts, bolts, washers, and lugs. Wire brush and apply inhibiting compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

### 3.9 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

### 3.10 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.

### 3.11 GROUNDING SYSTEMS

**NFPA 70** and **IEEE C2**, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

#### 3.11.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 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, an additional ground rod must be provided 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.

#### 3.11.2 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.

### 3.11.3 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.

### 3.11.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

## 3.12 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

### 3.12.1 Reconditioning of Surfaces

#### 3.12.1.1 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 top-soiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

#### 3.12.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

## 3.13 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

### 3.13.1 Concrete Slabs (Pads) for Equipment

Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches

from the top of the slab. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

### 3.14 FIELD QUALITY CONTROL

#### 3.14.1 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.

##### 3.14.1.1 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.

##### 3.14.1.2 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.

#### 3.14.2 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 --

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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 in 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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
- IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) 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 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)

National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-78-B	(2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-472D000	(2007b) Fiber Optic Communications Cable for Outside Plant Use
TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
ANSI/TIA-568.1-D	(2018) Commercial Building Telecommunications Cabling
ANSI/TIA-568.2-D	(2018) Balanced Twisted-Pair Telecommunications Cabling and Components
ANSI/TIA-568.3-D	(2016) Optical Fiber Cabling Components
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
ANSI/TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
ANSI/TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
ANSI/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

TIA-455-204 (2000) Standard for Measurement of Bandwidth on Multimode Fiber

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755 Telecommunications Standards and Specifications for Materials, Equipment and Construction

RUS Bull 345-50 (1979) Trunk Carrier Systems (PE-60)

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-640 (1995) Design of Buried Plant, Physical Considerations

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) UL Standard for Safety Thermoplastic-Insulated Wires and Cables

UL 497 (2001; Reprint Jul 2013) Protectors for Paired Conductor Communication Circuits

UL 510 (2017) 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 [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#), [ANSI/TIA-568.3-D](#), [ANSI/TIA-569](#), [TIA-606](#), [ANSI/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 new 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. 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 to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

[SD-02 Shop Drawings](#)

[Telecommunications Outside Plant; G](#)

Telecommunications Entrance Facility Drawings; G

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

Cable splices, and connectors; G

Splice cases and other closures; G

Building protector assemblies; G

Protector modules; G

Spare Parts; G

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

Acceptance tests; G

Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Building protector assembly installation; G

Cable tensions; G

Fiber Optic Splices; G

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

## SD-10 Operation and Maintenance Data

### Telecommunications outside plant (OSP), Data Package 5; G

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

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 ANSI/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 ANSI/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 ANSI/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 in accordance with [ANSI/TIA-606](#) that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and backboard 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. 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 [ANSI/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.

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, [ANSI/TIA-568.1-D](#), [ANSI/TIA-568.2-D](#) and [ANSI/TIA-568.3-D](#). 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 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-C.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 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 ANSI/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. Provide the following T5 drawing documentation as a minimum:

- a. Cables - A record of installed cable shall be provided in accordance with ANSI/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 ANSI/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 ANSI/TIA-606. Documentation shall include the required data fields in accordance with ANSI/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, screw type unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for 50 pairs of outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturer's 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 SPLICE CASES AND OTHER CLOSURES

#### 2.3.1 Copper Conductor Closures

##### 2.3.1.1 Aerial Cable Closures

Not used.

##### 2.3.1.2 Underground Cable Closures

- a. Direct burial: Provide buried stainless steel closure suitable for enclosing a straight, butt, and branch splice in a container into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity in the buried 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](#). 377MSG requires the use of stainless steel closures for copper conductors.
- b. In vault or manhole: Provide underground stainless steel 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 stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be re-enterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with **RUS Bull 345-72**. 377MSG requires the use of stainless steel closures for copper conductors.

### 2.3.2 Fiber Optic Closures

#### 2.3.2.1 Aerial

Not used.

#### 2.3.2.2 Direct Burial

Provide buried closure suitable to house splice organizer in protective housing into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity, when metallic, in buried environment. Encapsulating compound shall be re-enterable and shall not alter chemical stability of the closure.

#### 2.3.2.3 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 re-enterable and shall not alter the chemical stability of the closure.

### 2.4 PAD MOUNTED CROSS-CONNECT TERMINAL CABINETS

Not used.

### 2.5 CABLE SPLICES, AND CONNECTORS

#### 2.5.1 Copper Cable Splices

Provide multipair, in-line 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.

#### 2.5.2 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**.

### 2.5.3 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](#).

### 2.6 CONDUIT

Provide conduit as specified in Section [33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION](#).

### 2.7 PLASTIC INSULATING TAPE

[UL 510](#).

### 2.8 WIRE AND CABLE

#### 2.8.1 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:

##### 2.8.1.1 Underground

Provide filled cable meeting the requirements of [ICEA S-99-689](#) and [RUS 1755.890](#).

##### 2.8.1.2 Aerial

Not used.

##### 2.8.1.3 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of [ICEA S-99-689](#) and [RUS 1755.390](#).

#### 2.8.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with [TIA-492CAAA](#), [TIA-472D000](#), and [ICEA S-87-640](#) including any special requirements made necessary by a specialized design. Provide 12 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](#) and 377 MSG/SC Communications.

##### 2.8.2.1 Strength Members

Provide central, non-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.

#### 2.8.2.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with [ICEA S-87-640](#).

#### 2.8.3 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](#).

#### 2.9 T-SPAN LINE TREATMENT REPEATERS

Provide as indicated. Repeaters shall be pedestal mounted with non-pressurized housings, sized as indicated and shall meet the requirements of [RUS Bull 345-50](#).

#### 2.10 POLES AND HARDWARE

Not used.

#### 2.11 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 [ANSI/TIA-606](#). Handwritten labeling is unacceptable.

##### 2.11.1 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.

#### 2.12 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.

#### 2.13 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.

## 2.14 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.

## 2.15 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.

## 2.16 TESTS, INSPECTIONS, AND VERIFICATIONS

### 2.16.1 [Factory Reel Test Data](#)

Test 100 percent OTDR test of FO media at the factory in accordance with [ANSI/TIA-568.1-D](#) and [ANSI/TIA-568.3-D](#). Use [TIA-526-7](#) for single mode fiber and [TIA-526-14](#) Method B for multi mode fiber measurements. 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](#), 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.

### 3.1.1.3 Direct Burial System

Installation shall be in accordance with **RUS Bull 1751F-640**. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of **24 inches** below finished grade. Trenches shall be not less than **6 inches** wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than **36 inches**. Where two or more cables are laid parallel in the same trench, space laterally at least **3 inches** apart. When rock is encountered, remove it to a depth of at least **3 inches** below the cable and fill the space with sand or clean earth free from particles larger than **1/4 inch**. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section **31 00 00 EARTHWORK**.

#### 3.1.3.1 Cable Placement

- a. Separate cables crossing other cables or metal piping from the other cables or pipe by not less than **3 inches** of well tamped earth. Do not install circuits for communications under or above traffic signal loops.
- b. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.
- c. 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.
- d. Leave a horizontal slack of approximately **3 feet** in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought aboveground. Where cable is brought aboveground, leave additional slack to make necessary connections.

#### 3.1.3.2 Identification Markers

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately **20 inches** square by **6 inches** thick.

#### 3.1.3.3 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least **2 inches** thick on the floor of the trench before placing the cable or wire. The backfill for at least **4 inches** above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than **24 inches** in depth, a protective cover of concrete shall be used.



#### 3.1.4 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.

##### 3.1.4.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cable 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.

#### 3.1.5 Underground Duct

Provide underground duct and connections to existing handholes as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

#### 3.1.6 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

#### 3.1.7 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.

#### 3.1.8 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. 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.

#### 3.1.8.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

#### 3.1.8.2 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.

#### 3.1.8.3 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.

### 3.1.9 Aerial Cable Installation

#### 3.1.9.1 Figure 8 Distribution Wire

Perform spiraling of the wire within 24 hours of the tensioning operation. Perform spiraling operations at alternate poles with the approximate length of the spiral being 15 feet. Do not remove insulation from support members except at bonding and grounding points and at points where ends of support members are terminated in splicing and dead-end devices. Ground support wire at poles to the pole ground.

#### 3.1.9.2 Suspension Strand

Place suspension strand as indicated. Tension in accordance with the data indicated. When tensioning strand, loosen cable suspension clamps enough to allow free movement of the strand. Place suspension strand on the road side of the pole line. In tangent construction, point the lip of the suspension strand clamp toward the pole. At angles in the line, point the suspension strand clamp lip away from the load. In level construction place the suspension strand clamp in such a manner that it will hold the strand below the through-bolt. At points where there is an up-pull on the

strand, place clamp so that it will support strand above the through-bolt. Make suspension strand electrically continuous throughout its entire length, bond to other bare cables suspension strands and connect to pole ground at each pole.

### 3.1.9.3 Aerial Cable

Keep cable ends sealed at all times using cable end caps. Take cable from reel only as it is placed. During placing operations, do not bend cables in a radius less than 10 times the outside diameter of cable. Place temporary supports sufficiently close together and properly tension the cable where necessary to prevent excessive bending. In those instances where spiraling of cabling is involved, accomplish mounting of enclosures for purposes of loading, splicing, and distribution after the spiraling operation has been completed.

### 3.1.10 Cable Splicing

#### 3.1.10.1 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.

#### 3.1.10.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.2 dB for fusion splices.

#### 3.1.11 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](#).

#### 3.1.12 Grounding

Provide grounding and bonding in accordance with [RUS 1755.200](#), [ANSI/TIA-607](#), [IEEE C2](#), and [NFPA 70](#). Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

##### 3.1.12.1 Telecommunications Master Ground Bar (TMGB)

The TMGB 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 TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM.

##### 3.1.12.2 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 TMGB.

##### 3.1.12.3 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 TMGB.

- b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

### 3.2 LABELING

#### 3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with ANSI/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 only new wire and cable provided by this contract. The labeling of telecommunications cable tag identifiers shall be in accordance with ANSI/TIA-606. 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

Not used.

### 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 10 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.

#### 3.5.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

#### 3.5.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

#### 3.5.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

### 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 14 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 [ANSI/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. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. 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-bends 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, 300 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 and TIA-526-14 for multimode fiber. Splice losses shall not exceed 0.3 db.
- b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 1310 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. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.
- c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA-455-204.

### 3.5.3 Soil Density Tests

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
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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
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AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B30.2	(2017) 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 A668/A668M (2022) 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 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 (2016) Motors and Generators - Revision  
1: 2018; Includes 2021 Updates to Parts  
0, 1, 7, 12, 30, and 31



NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022)  
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 Feb 2018) 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) 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: One crane, located in building identified as CRH Simulator Facility 951B, with the capacity expressed in 2.5 tons, for each overhead electric traveling (OET) crane.

##### 1.3.1.2 Classification

Provide top running overhead electric traveling (OET) multiple girder crane conforming to CMAA 70 service class C for operation in an indoor environment, general purpose service, meeting the requirements of ASME B30.2, with an ambient temperature range of 50 to 110 degrees Fahrenheit. The crane span must be approximately 56 feet 4 inches with a vertical lift of 36 feet 8 inches and as specified herein.

The crane must be radio controlled and operate in the spaces and within the loading conditions indicated. 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 2.5 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	15	1.5
Trolley	60	6
Bridge	60	6

#### 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

Complete Schematic Wiring Diagram; G

##### SD-03 Product Data

Gear Reducers; G

Hoist Brakes; G

Travel Brakes; G

Load Blocks and Hooks; G

Wheels; G

Hoists; G

Sheaves; G

Commercial Hoist and Trolley Units; G

End Trucks; G

Bridge Rails; G

End Stops; G

Bumpers; G

Variable Frequency Drives; G

Motors; G

Runway Conductor System; G

Bridge Conductor System; G

Limit Switches; G

Radio Control System; G

Controls; G

Control Parameter Settings; G

Capacity Overload Protective Device; G

Painting System; G

#### SD-05 Design Data

Load and Sizing Calculations; G

#### SD-06 Test Reports

Hook Proof Test; G

Post-erection Inspection; G

Operational Tests; G

Hook Tram Measurement; G

Load Tests; G

#### SD-07 Certificates

Wire Ropes; G

Crane Runway System; G

Hazardous Material; G

Loss of Power Test; G

Coupling Alignment Verification Record; G

Overload Test; G

Brake Adjustment Record; G

Compliance with Listed Standards; G

Software and Services; G

#### SD-10 Operation and Maintenance Data

## Operation and Maintenance Manuals; G

### SD-11 Closeout Submittals

#### 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 load-carrying steel castings. 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 prior to delivery. Furnish documentation of hook inspection (Hook Proof Test) 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.

###### 1.6.2.3 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](#).
  - f. Submit an [Overload Test](#) Certificate stating that the crane can be periodically load tested to 125 percent (plus 0 minus 5 percent) of rated load.
  - g. 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.
  - h. Submit a Certificate of [Compliance with Listed Standards](#)
  - i. The Contractor shall provide a certificate stating that all [Software and Services](#) that are not required for operation and/or maintenance of the product have been removed. The software/services to be removed are identified in paragraph SOFTWARE AND SERVICES.
- 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.

#### 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.

#### 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 Rails

Provide and install [ASCE 30](#) runway rails. Stagger joints on the two rails. Align rails in compliance with [CMAA 70](#). Bridge stops are to be located and installed during crane installation.

### 2.2.2 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](#).

### 2.2.3 Bridge Girder or Girders

Provide wide flange beam, standard I-Beam, or section fabricated from rolled plates and shapes bridge 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.

### 2.2.4 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.

#### 2.2.5 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.

#### 2.2.6 End Trucks

Provide fixed axle 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.

#### 2.2.7 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.

#### 2.2.8 End Stops and Bumpers

Fit bridge girders with structural steel end stops. [Stops to be located during installation.](#) 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. [Metal to metal contact at the bumper to end stop connection is not permitted.](#)

#### 2.2.9 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.
- 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.

Standard [commercial hoist and trolley units](#) (packaged hoists), if used, must meet [ASME HST-4](#) Duty Class H1 or better. For custom hoist shafts, the fatigue design factor must be a minimum of 1.5.

#### 2.3.2 Drives

##### 2.3.2.1 Bridge Drives

Provide 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. Standard commercial blocks may be used at their published ratings when their published design factors are 5.0 or greater.

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. Uniquely mark the hook in a permanent fashion that is traceable to the NDT certification.

The hook nut must be of non-sparking materials. 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. Upper hooks of hook suspended hoists shall be of non-sparking materials.

#### 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 splintered 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. A mechanical load brake may be utilized in lieu of one of the hoist holding brakes provided it stops and holds 125 percent of the hoist's rated load and does not require the load to be raised before being lowered.

- 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. On drives where the brakes are utilized as holding brakes only, torque adjustment is not required. The brakes must be equipped with a manual self-return to ON brake release and designed to permit inspection and adjustment without disassembly of the brake.

## 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 motors with a minimum of Class F insulation. Provide motor overload protection utilizing a thermal sensitive device embedded in its windings. Provide motors painted to manufacturer's standard for "wash-down" service. Motors located outdoors must be furnished with anti-condensation heaters that remain energized when the mainline contactor is deenergized.

### 2.4.2 Controls

- a. Provide static reversing, variable frequency drives (VFD) for the bridge, trolley, and hoist electric controls. The hoist controller must enable the drive motor to develop full torque continuously at zero speed. The hoist secondary brake shall be controlled separate from the primary and connected to different output (within the drive) from the primary brake. 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 radio control system.
- c. 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.

- d. 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.
- e. 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.
- f. 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.
- g. 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 and/or radio controllers. 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. When mounted outdoors provide stainless steel resistor enclosures. 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

- a. Limit switches must be rated for the NEC Hazardous Classifications specified in the Classification section of this specification.
- 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 and 5 feet from the trolley 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 radio control system.
- b. If VFD controls are not provided, provide directional contactors with both mechanical and electrical interlocks.

##### 2.4.7.1 Radio Control System

Provide each system with a handheld type portable transmitter unit and an identical back-up transmitter unit. Only one transmitter at a time can control the crane and there must be no interference from one crane's controller affecting operation of the other cranes in the building. Each transmitter must include: individual push button controls for each hoist, trolley, and bridge; a maintained contact, keyed switch, marked ON-OFF, for portable transmitter unit power; indication of Battery Power, and indication of Transmitting Status; a red emergency STOP mushroom pushbutton.

The transmitters and all controls must each be clearly and permanently labeled with functionality and direction. Directions for controllers must be in accordance with CMAA 70 recommendations. The remote radio control system must be designed to meet the requirements of NEMA ICS 8, Part 9 and ECMA 15. Each radio remote control lever must be in the OFF position before the associated crane function can begin. The system frequency must be within the unlicensed FCC Part 15 range. Each control unit must maintain a continuous status signal to the associated receiver during operation. There must be no significant loss in systems efficiency and



function at the end of eight hours of continuous battery use. Provide a contact monitoring board with the crane radio system receiver.

#### 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. UV resistant. Steel (non-stainless) conductor bars are prohibited. The crane must be grounded through the runway electrification system. The grounded conductors must be a minimum of 70 square millimeters. 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.
- b. Provide two Collector Shoes (tandem design) for each conductor; each collector shoe must be rated for not less than the overcurrent protective device for the runway conductor system, so as to provide redundancy.
- c. Provide a Festoon System for the runway conductor system utilizing cables suspended from carriers riding on an I-beam or C-track for the crane, 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. Conductors must be fabricated from copper. The crane is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG. Provide conductors sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. Festooned cable loops must not extend low enough to come into contact with any obstructions.
- d. Provide a Cable Reel System for the runway conductor system, including all necessary cables and hardware to connect the cable reel to the floor level fused disconnect switch. The cable reel must have three power conductors and an equipment grounding conductor. The crane is required to be grounded through this conductor system. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The grounded conductors must be a minimum of 2/0 AWG.
- e. Provide a totally enclosed flexible cable tray electrification system (cable chain) for the runway conductor system, including all necessary cables and hardware to the crane from a wall or column mounted disconnect switch. The cable chain must have three power conductors and an equipment grounding conductor. The conductors must be selected so as to be of the longest length without splices. Conductors must be fabricated from copper, and sized for simultaneous motions of the hoist, bridge, trolley mechanisms and any ancillary loads. The crane is required to be grounded through this conductor system. The grounded conductors must be a minimum of 2/0 AWG.

#### 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. **The grounded conductors must be a minimum of 2/0 AWG.** Festooned cable loops must not extend low enough to come into contact with any obstructions.
- b. Provide a Cable Reel System for the bridge conductor system. The cable reel must have three power conductors, an equipment grounding conductor, and all necessary control cables. 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 must be grounded through the cable reel connection and all conductors must be of copper construction. **The grounded conductors must be a minimum of 2/0 AWG.**

#### 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 100. 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. 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 2 indoor, drip-proof. 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 radio control station. Provide a warning rotating beacon 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. 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

**Not Used.**

### 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 Bridge and Trolley Travel Stops

**Locate and install bridge and trolley travel stops at locations determined by users.**

#### 3.3.3 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.

#### 3.3.4 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**.

### 3.3.5 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 30 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 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 (plus 0 minus 10) of rated load.

Overload test: 125 percent (plus 0 minus 5) 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

Not Used.

### 3.8 FINAL ACCEPTANCE

Not Used.

-- End of Section --

