# VIGO COUNTY
# SECURITY CENTER

**Terre Haute, Indiana**

**PROJECT MANUAL**
**Volume 4**
**Specification Divisions 26 - 33**

**CONSTRUCTION DOCUMENTS**

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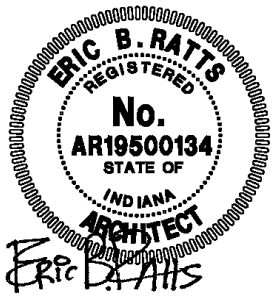
**SET NUMBER:** _____

SIGNATURE SHEET FOR

# Vigo County
# Security Center

Terre Haute, Indiana

**Each seal applies to its designated discipline.**

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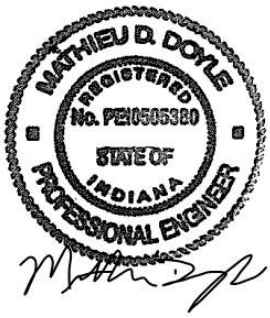


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# SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Aluminum building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 271313 "Communications Copper Backbone Cabling" for twisted pair cabling used for data circuits.
2. Section 271513 "Communications Copper Horizontal Cabling" for twisted pair cabling used for data circuits.

### 1.3 DEFINITIONS

A. VFC: Variable-frequency controller.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

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

1. Thomas & Betts Corporation: A Member of the ABB Group.
2. Cooper Industries, Inc.
3. Belden Inc.
4. Cerro Wire LLC.
5. Encore Wire Corporation.
6. General Cable Technologies Corporation.
7. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 or ASTM B496 for stranded conductors.

E. Conductor Insulation:

1. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
2. Type THHN and Type THWN-2: Comply with UL 83.
3. Type XHHW-2: Comply with UL 44.

F. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

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

1. Belden Inc.
2. Cerro Wire LLC.
3. Encore Wire Corporation.
4. General Cable Technologies Corporation.
5. Southwire Company.
6. Thomas & Betts Corporation: A Member of the ABB Group.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

E. Conductor Insulation:

1. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
2. Type THHN and Type THWN-2: Comply with UL 83.
3. Type XHHW-2: Comply with UL 44.

4. Type TFN/THHN/THWN-2: Comply with UL 83.
5. Type XHHW-2: Comply with UL 44.

## 2.3 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

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

1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. ILSCO.
6. NSi Industries LLC.
7. O-Z/Gedney; a brand of Emerson Industrial Automation.
8. Thomas & Betts Corporation; A Member of the ABB Group.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

## PART 3 - EXECUTION

### 3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 1/0 AWG; copper or aluminum for feeders No. 1/0 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

D. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

### 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. VFC Output Circuits: Type TC-ER cable with braided shield.

## 3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

## 3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

## 3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

## 3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

## 3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

## 3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements:

    a. Switchboards.

    b. Panelboards.

    c. Generator.

    d. Automatic Transfer Switches.

3. Perform each of the following visual and electrical tests:

    a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
    b. Test bolted connections for high resistance using one of the following:

        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.
        3) Thermographic survey.

    c. Inspect compression-applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.
    e. Inspect cable jacket and condition.
    f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
    g. Continuity test on each conductor and cable.

h. Uniform resistance of parallel conductors.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

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# SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.

### 1.3 ACTION SUBMITTALS

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

### 1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Field quality-control reports.

### 1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:

1) Test wells.

2) Ground rods.
3) Ground rings.
4) Grounding arrangements and connections for separately derived systems.

b. Instructions for periodic testing and inspection of grounding features at test wells , ground rings, and grounding connections for separately derived systems based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

### 2.2 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO; a brand of nVent.
3. Harger Lightning & Grounding.
4. ILSCO.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. Siemens Industry, Inc., Energy Management Division.
7. Thomas & Betts Corporation; A Member of the ABB Group.

### 2.3 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

## 2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt .

I. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

J. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

K. Water Pipe Clamps:

1. Mechanical type, two pieces with zinc-plated bolts.

    a. Material: Die-cast zinc alloy.
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 1/0 AWG minimum.

1. Bury at least 30 inches below grade.

C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

## 3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

E. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

## 3.6 FENCE GROUNDING

A. Fence Grounding: Install at maximum intervals of [**1500 feet**] <**Insert a lesser distance if grounding resistance is high**> except as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [**750 feet**] <**Insert a lesser distance if grounding resistance is high**>.

a. Gates and Other Fence Openings: Ground fence on each side of opening.

1) Bond metal gates to gate posts.
2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.

D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

## 3.7 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Use exothermic welds for all below-grade connections.
3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange.

Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of area or item indicated.

1. Install tinned-copper conductor not less than No. 1/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring 30 inches and locate away from building's foundation not less than 24 inches.

I. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

## 3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

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

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 5 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

# SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment-support assemblies.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

## 1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
2. Component Importance Factor: [**1.5**] [**1.0**].

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

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

a. ERICO International Corporation.
b. Allied Tube & Conduit; a part of Atkore International.
c. B-line, an Eaton business.
d. GS Metals Corp.
e. Thomas & Betts Corporation; A Member of the ABB Group.
f. Unistrut; Part of Atkore International.
g. Wesanco, Inc.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.

3. Material for Channel, Fittings, and Accessories: Galvanized steel unless otherwise indicated on Electrical Drawings. Stainless steel, Type 304 as indicated on Electrical Drawings.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Match Material for hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

        1) Hilti, Inc.
        2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

        1) B-line, an Eaton business.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

## 2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

# PART 3 - EXECUTION

## 3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 102.
4. NECA 105.
5. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

## 3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may NOT be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

## 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

## 3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete unless otherwise specified or indicated on Structural Drawings and Specifications. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

## 3.5 PAINTING

A. Touchup: Comply with requirements in Section 099113 "Exterior Painting" or Section 099123 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 260529

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# SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

### 1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

### 1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

### 1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

3. Cable Tray.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

## PART 2 - PRODUCTS

### 2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

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

a. AFC Cable Systems; a part of Atkore International.
b. Allied Tube & Conduit; a part of Atkore International.
c. Anamet Electrical, Inc.
d. Electri-Flex Company.
e. O-Z/Gedney; a brand of Emerson Industrial Automation.
f. Picoma Industries, Inc.
g. Republic Conduit.
h. Southwire Company.
i. Thomas & Betts Corporation; A Member of the ABB Group.
j. Western Tube and Conduit Corporation.
k. Wheatland Tube Company.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. GRC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

a. Comply with NEMA RN 1.

b. Coating Thickness: 0.040 inch, minimum.

6. EMT: Comply with ANSI C80.3 and UL 797.
7. FMC: Comply with UL 1; zinc-coated steel.
8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

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

a. AFC Cable Systems; a part of Atkore International.
b. Allied Tube & Conduit; a part of Atkore International.
c. Anamet Electrical, Inc.
d. Electri-Flex Company.
e. O-Z/Gedney; a brand of Emerson Industrial Automation.
f. Picoma Industries, Inc.
g. Republic Conduit.
h. Southwire Company.
i. Thomas & Betts Corporation; A Member of the ABB Group.
j. Western Tube and Conduit Corporation.
k. Wheatland Tube Company.

2. Comply with NEMA FB 1 and UL 514B.

3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Fittings for EMT:

a. Material: Steel.
b. Type: Compression.

6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

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

    a. AFC Cable Systems; a part of Atkore International.
    b. Anamet Electrical, Inc.
    c. Arnco Corporation.
    d. CANTEX INC.
    e. CertainTeed Corporation.
    f. Electri-Flex Company.
    g. Kraloy.
    h. Lamson & Sessions.
    i. Niedax Inc.
    j. RACO; Hubbell.
    k. Thomas & Betts Corporation; A Member of the ABB Group.

2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:

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

    a. AFC Cable Systems; a part of Atkore International.
    b. Anamet Electrical, Inc.
    c. Arnco Corporation.
    d. CANTEX INC.
    e. CertainTeed Corporation.
    f. Electri-Flex Company.
    g. Kraloy.
    h. Lamson & Sessions.
    i. Niedax Inc.
    j. RACO; Hubbell.
    k. Thomas & Betts Corporation; A Member of the ABB Group.

2. Fittings, General: Listed and labeled for type of conduit, location, and use.

3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

    a. Fittings for LFNC: Comply with UL 514B.

4. Solvents and Adhesives: As recommended by conduit manufacturer.

## 2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. B-line, an Eaton business.
2. Hoffman; a brand of nVent.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

## 2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.

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

a. Hubbell Incorporated; Wiring Device-Kellems.
b. MonoSystems, Inc.
c. Panduit Corp.
d. Wiremold / Legrand.

## 2.5 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.

2. Crouse-Hinds, an Eaton business.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman; a brand of nVent.
7. Hubbell Incorporated.
8. Kraloy.
9. Milbank Manufacturing Co.
10. MonoSystems, Inc.
11. Oldcastle Enclosure Solutions.
12. O-Z/Gedney; a brand of Emerson Industrial Automation.
13. RACO; Hubbell.
14. Spring City Electrical Manufacturing Company.
15. Thomas & Betts Corporation; A Member of the ABB Group.
16. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Nonmetallic Floor Boxes: Nonadjustable, round.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (double gang); 4 inches by 2-1/8 inches by 2-1/8 inches deep (single gang).

K. Gangable boxes are prohibited.

L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

M. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

## 2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

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

a. Oldcastle Enclosure Solutions.
b. Oldcastle Precast, Inc.
c. Quazite: Hubbell Power Systems, Inc.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT or IMC.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    a. Mechanical rooms.
    b. Inmate occupied rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not fasten conduits onto the bottom side of a pre-cast concrete ceiling.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of four (4) 90-degree bends in any conduit run except for control wiring conduits (for which fewer bends, not to exceed two (2) 90-degree bends) are allowed. Support within 12 inches of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from GRC before rising above floor.

M. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

P. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

Q. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

R. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

S. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

T. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

U. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a

blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

V. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Where otherwise required by NFPA 70.

W. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

X. Expansion-Joint Fittings:

1. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

2. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer’s written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

Y. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

Z. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

AA. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

BB. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

CC. Locate boxes so that cover or plate will not span different building finishes.

DD. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

EE. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

FF. Set metal floor boxes level and flush with finished floor surface.

GG. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

## 3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

## 3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line, below grade.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

## 3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install 0sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

## 3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

## 3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

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# SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

## PART 2 - PRODUCTS

### 2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## 2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.
e. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

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

a. Presealed System.

b. HOLDRITE.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

## 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

## 3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

# SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.

a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

## 1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Electrical components include:

1. Control and monitoring panels.
2. Generators.
3. Luminaires.
4. Motor control centers.
5. Panelboards.
6. Switchboards.
7. Switchgear.
8. Transformers.

B. Qualification Data: For testing agency.

C. Welding certificates.

D. Field quality-control reports.

## 1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC:III.

a. Component Importance Factor:1.5
b. Component Response Modification Factor: 1.5
c. Component Amplification Factor: 1.0.

### 2.2 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

### 2.3 RESTRAINT CABLES

A. Restraint Cables: ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.6 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive [**vibration isolation and** ]seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

## 3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

## 3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

## 3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

## 3.5 FIELD QUALITY CONTROL

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

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

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548.16

# SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

C. Delegated-Design Submittal: For arc-flash hazard study.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

## 2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 240-V Circuits:

a. Phase A: Black.
b. Phase B: Red.

4. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

5. Color for Neutral: White.
6. Color for Equipment Grounds: Bare copper, Green, or Green with a yellow stripe.
7. Colors for Isolated Grounds: Green with two or more yellow stripes.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

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

a. Brady Corporation.
b. Champion America.
c. emedco.
d. Grafoplast Wire Markers.
e. HellermannTyton.
f. LEM Products Inc.
g. Marking Services, Inc.
h. Panduit Corp.
i. Seton Identification Products.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.
e. Seton Identification Products.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

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

    a. A'n D Cable Products.
    b. Brady Corporation.
    c. Brother International Corporation.
    d. emedco.
    e. Grafoplast Wire Markers.
    f. Ideal Industries, Inc.
    g. LEM Products Inc.
    h. Marking Services, Inc.
    i. Panduit Corp.
    j. Seton Identification Products.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

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

    a. A'n D Cable Products.
    b. Brady Corporation.
    c. Brother International Corporation.
    d. emedco.
    e. Grafoplast Wire Markers.
    f. HellermannTyton.
    g. Ideal Industries, Inc.
    h. LEM Products Inc.
    i. Marking Services, Inc.
    j. Panduit Corp.
    k. Seton Identification Products.

2. Minimum Nominal Size:

    a. 1-1/2 by 6 inches for raceway and conductors.
    b. 3-1/2 by 5 inches for equipment.
    c. As required by authorities having jurisdiction.

## 2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.

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

    a. Brady Corporation.
    b. HellermannTyton.
    c. Marking Services, Inc.
    d. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

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

    a. Brady Corporation.
    b. Panduit Corp.

## 2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

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

    a. Carlton Industries, LP.
    b. Champion America.
    c. HellermannTyton.
    d. Ideal Industries, Inc.
    e. Marking Services, Inc.
    f. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

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

    a. Brady Corporation.
    b. Carlton Industries, LP.
    c. emedco.
    d. Marking Services, Inc.

C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and are 12 inches wide. Stop stripes at legends.

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

    a. HellermannTyton.
    b. LEM Products Inc.
    c. Marking Services, Inc.
    d. Seton Identification Products.

D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

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

    a. Carlton Industries, LP.
    b. Seton Identification Products.

E. Underground-Line Warning Tape:

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

    a. Brady Corporation.
    b. Ideal Industries, Inc.
    c. LEM Products Inc.
    d. Marking Services, Inc.
    e. Reef Industries, Inc.
    f. Seton Identification Products.

2. Tape:

    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

    a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
    c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag: Type ID:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches.
c. Overall Thickness: 5 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft..
f. Tensile according to ASTM D882: 70 lbf and 4600 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.
e. Seton Identification Products.

B. Write-on Tags:

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

a. Carlton Industries, LP.
b. LEM Products Inc.
c. Seton Identification Products.

2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

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

a. Carlton Industries, LP.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

2. Preprinted aluminum signs,punched or drilled for fasteners, with colors, legend, and size required for application.

3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches.

B. Metal-Backed Butyrate Signs:

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

a. Brady Corporation.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.

3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

2. Engraved legend.

3. Thickness:

a. For signs up to 20 sq. in., minimum 1/16 inch thick.
b. For signs larger than 20 sq. in., 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

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

1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services, Inc.
4. Panduit Corp.

B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

I. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

V. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

W. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

X. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

Y. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

Z. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

AA. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

BB. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

## 3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl tape applied in bands.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

J. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

K. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.
b. Controls with external control power connections.

N. Arc Flash Warning Labeling: Self-adhesive labels.

O. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

P. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

Q. Equipment Identification Labels:

1. Indoor Equipment: Engraved, Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Variable-speed controllers.
n. Push-button stations.
o. Power-transfer equipment.
p. Contactors.
q. Remote-controlled switches, dimmer modules, and control devices.
r. Battery-inverter units.
s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. UPS equipment.

END OF SECTION 260553

# SECTION 260573.13 - SHORT-CIRCUIT STUDIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

### 1.3 DEFINITIONS

A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

D. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

F. SCCR: Short-circuit current rating.

G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

H. Single-Line Diagram: See "One-Line Diagram."

### 1.4 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.

2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

    a. Short-circuit study input data, including completed computer program input data sheets.
    b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

        1) Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
        2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
2. The following are from the Short-Circuit Study Report:

    a. Final one-line diagram.
    b. Final Short-Circuit Study Report.
    c. Short-circuit study data files.
    d. Power system data.

## 1.7 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.

F. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

## PART 2 - PRODUCTS

### 2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

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

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.
6. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
6. Derating factors and environmental conditions.
7. Any revisions to electrical equipment required by the study.

D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.
2) Based on calculated symmetrical value multiplied by 1.6.
3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

## PART 3 - EXECUTION

### 3.1 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the study.

1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Architect's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study and shall be by the engineer or its representative who holds

NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
11. Derating factors.

## 3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also

account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Include in the report identification of any protective device applied outside its capacity.

## 3.3 ADJUSTING

Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

END OF SECTION 260573.13

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# SECTION 260573.16 - COORDINATION STUDIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

### 1.3 DEFINITIONS

A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

D. Power System Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

F. SCCR: Short-circuit current rating.

G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

a. Coordination-study input data, including completed computer program input data sheets.
b. Study and equipment evaluation reports.

3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power System Analysis Software Developer.
2. For Power Systems Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

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

1. The following are from the Coordination Study Report:

a. Final one-line diagram.
b. Final protective device coordination study.
c. Coordination study data files.
d. List of all protective device settings.
e. Time-current coordination curves.
f. Power system data.

1.7 QUALITY ASSURANCE

A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications:

1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

F. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

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

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.
6. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Any revisions to electrical equipment required by the study.

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

a. Phase and Ground Relays:

1) Device tag.
2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, and ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.
    b. Medium-voltage equipment overcurrent relays.
    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f. Cables and conductors damage curves.
    g. Ground-fault protective devices.
    h. Motor-starting characteristics and motor damage points.
    i. Generator short-circuit decrement curve and generator damage point.
    j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

### 3.2 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
17. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.

g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

## 3.3 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.

K. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Include in the report identification of any protective device applied outside its capacity.

## 3.4 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

## 3.5 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 260573.16

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# SECTION 260573.19 - ARC-FLASH HAZARD ANALYSIS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

### 1.3 DEFINITIONS

A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

D. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

F. SCCR: Short-circuit current rating.

G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

H. Single-Line Diagram: See "One-Line Diagram."

### 1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form:

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by Power Systems Analysis Specialist.
3. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Provide maintenance procedures in equipment manuals according to requirements in NFPA 70E.
2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.

G. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

## PART 2 - PRODUCTS

### 2.1 COMPUTER SOFTWARE DEVELOPERS

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

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.
6. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

### 2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

G. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Protection boundaries.

a. Arc-flash boundary.
b. Restricted approach boundary.
c. Limited approach boundary.

4. Arc flash PPE category.
5. Required minimum arc rating of PPE in Cal/cm squared.
6. Available incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.

D. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.

F. Calculate the limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors shall not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

## 3.3 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on one-line diagram on Drawings. Call discrepancies to Architect's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance or available short circuit current at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Motor horsepower and NEMA MG 1 code letter designation.
13. Low-voltage conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

## 3.4 LABELING

A. Apply one arc-flash label on the front cover of each section of the equipment for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below shall have an arc-flash label applied to it:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Low voltage transformers.

5. Panelboard and safety switch over 250 V.
6. Applicable panelboard and safety switch under 250 V.
7. Control panels.

C. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

## 3.5 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under the direct supervision and control of Power System Analysis Specialist.

## 3.6 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels.

END OF SECTION 260573.19

# SECTION 260923 - LIGHTING CONTROL DEVICES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Photoelectric switches.
2. Standalone daylight-harvesting switching and dimming controls.
3. Indoor occupancy and vacancy sensors.
4. Switchbox-mounted occupancy sensors.
5. High-bay occupancy sensors.
6. Outdoor motion sensors.
7. Lighting contactors.
8. Emergency shunt relays.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

### 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES, SOLID STATE, FLEXIBLE MOUNTING

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

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. NSi Industries LLC.

B. Description: Solid state, with DPST dry contacts rated for 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a agency NRTL, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with ANSI C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
6. Failure Mode: Luminaire stays ON.

2.2 DAYLIGHT-HARVESTING DIMMING CONTROLS, DIGITAL

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. WattStopper; a Legrand® Group brand.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.

1. Lighting control set point is based on the following two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. System programming is done with two hand-held, remote-control tools.

a. Initial setup tool.
b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated or separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

E. Power Pack: Digital controller capable of accepting three RJ45 inputs with two output(s) rated for 20-A incandescent or LED load at 120- and 277-V ac, for 16-A LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.

1. With integral current monitoring.
2. Compatible with digital addressable lighting interface.
3. Plenum rated.

## 2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.

4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. NSi Industries LLC.
7. Sensor Switch, Inc.
8. WattStopper; a Legrand® Group brand.

B. General Requirements for Sensors:

1. Wall or Ceiling-mounted, solid-state indoor occupancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. PIR Type: Wall or Ceiling mounted; detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.

3. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 feet when mounted on a 10-foot-high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet when mounted 48 inches above finished floor.

D. Ultrasonic Type: Wall or Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch-high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch-high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot-high ceiling in a corridor not wider than 14 feet.
6. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet when mounted 84 inches above finished floor.

E. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet when mounted48 inches above finished floor.

## 2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.

4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. NSi Industries LLC.
7. Sensor Switch, Inc.
8. WattStopper; a Legrand® Group brand.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Dual voltage - 120 and 277 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
9. Color: As selected by the Architect.
10. Faceplate: Color matched to switch.

D. Wall-Switch Sensor Tag WS2:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: PIR.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Dual voltage, 120 and 277 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

9. Color: As selected by the Architect.
10. Faceplate: Color matched to switch.

## 2.5 HIGH-BAY OCCUPANCY SENSORS

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

1. Hubbell Building Automation, Inc.

B. Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
4. Power: Line voltage.
5. Operating Ambient Conditions: 32 to 149 deg F.
6. Mounting: Threaded pipe.
7. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
8. Detector Technology: PIR.

C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet.

D. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

## 2.6 OUTDOOR MOTION SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. NSi Industries LLC.
6. Sensor Switch, Inc.
7. WattStopper; a Legrand® Group brand.

B. Description: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. [PIR] [Dual-technology (PIR and ultrasonic)] type, weatherproof. Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.. Comply with UL 773A.
3. Switch Rating:

    a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED.
    b. Separately Mounted Sensor: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Dual voltage, 120- and 277-V type.
6. Detector Coverage:

    a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft.
    b. Long Range: 180-degree field of view and 110-foot detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
10. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as "raintight" according to UL 773A.

## 2.7 LIGHTING CONTACTORS

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

1. Allen-Bradley/Rockwell Automation.
2. ASCO: a brand of Vertiv.
3. Eaton.
4. General Electric Company.
5. Square D.
6. Siemens

B. Description: Electrically operated and mechanically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).

2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

## 2.8 EMERGENCY SHUNT RELAY

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

1. Lighting Control and Design.
2. WattStopper; a Legrand® Group brand.

B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 277 V.

## 2.9 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

## 3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

## 3.3 CONTACTOR INSTALLATION

A. Comply with NECA 1.

## 3.4 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

## 3.5 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

## 3.6 FIELD QUALITY CONTROL

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

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

## 3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 2 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to one visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

## 3.8 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

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# SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

### 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Certification: Indicate that equipment meets Project seismic requirements.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Acme Electric Corporation.
2. Controlled Power Company; an Emerson company.
3. Eaton.
4. Federal Pacific.
5. General Electric Company.
6. Siemens Industry, Inc., Energy Management Division.
7. Sola/Hevi-Duty; a brand of Emerson Electric Co.
8. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

## 2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

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

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

## 2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.

D. Coils: Continuous windings without splices except for taps.

1. Coil Material: Aluminum or Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

F. Enclosure: Totally enclosed, nonventilated.

1. NEMA 250, Type 3R: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.

a. Finish Color: Gray weather-resistant enamel.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

K. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

M. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

N. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

O. Wall Brackets: Manufacturer's standard brackets.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9.01 to 30.00 kVA: 45 dBA.
2. 30.01 to 50.00 kVA: 45 dBA for K-factors of 1, 4, and 9; 48 dBA for K-factors of 13 and 20.
3. 50.01 to 150.00 kVA: 50 dBA for K-factors of 1, 4, and 9; 53 dBA for K-factors of 13 and 20.
4. 150.01 to 300.00 kVA: 55 dBA for K-factors of 1, 4, and 9; 58 dBA for K-factors of 13 and 20.
5. 300.01 to 500.00 kVA: 60 dBA for K-factors of 1, 4, and 9; 63 dBA for K-factors of 13 and 20.

## 2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

## 2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.

5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

### 3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

## 3.3 CONNECTIONS

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

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

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

## 3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.

c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Perform specific inspections and mechanical tests recommended by manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Measure resistance at each winding, tap, and bolted connection.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

C. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:

a. Visual and Mechanical Inspection:
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify that resilient mounts are free and that any shipping brackets have been removed.
e. Verify the unit is clean.
f. Perform specific inspections and mechanical tests recommended by manufacturer.
g. Verify that as-left tap connections are as specified.
h. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Measure resistance at each winding, tap, and bolted connection.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
c. Perform power-factor or dissipation-factor tests on all windings.
d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
e. Perform an excitation-current test on each phase.

f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.

3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

## 3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

## 3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

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# SECTION 262313 - PARALLELING LOW-VOLTAGE SWITCHGEAR

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes: Metal-enclosed, low-voltage, circuit-breaker switchgear rated 600 V and less, and associated monitoring and control systems for paralleling standby generators on an isolated bus and for distributing electrical power.

B. Related Requirements:

1. Section 260913 "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

### 1.3 DEFINITIONS

A. ATS: Acceptance Testing Specification.

B. DDC: Direct digital control.

C. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of paralleling low-voltage switchgear.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, and display components.
2. Include rated capacities, operating characteristics, furnished specialties, factory settings, and accessories for individual circuit breakers.
3. Include time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For each type of paralleling low-voltage switchgear.

1. Include dimensioned plans, elevations, sections, details, shipping sections, weights of each assembled section, and required clearances and service space around equipment.
2. Include tabulation of installed devices with features and ratings.
3. Include enclosure types and details.

4. Detail locations for anchor bolts.
5. Show bus configuration with current rating, size, and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
6. Indicate short-time and short-circuit current rating of switchgear assembly.
7. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Detail nameplate legends.
9. Include mimic-bus diagram.
10. Include three-line power wiring diagrams for paralleling low-voltage switchgear, generators, and related equipment showing device terminal numbers.
11. Include point-to-point schematic control, monitoring, and alarm wiring diagrams showing internal component terminal numbers.
12. Include point-to point schematic control, monitoring, and alarm wiring diagrams for external components indicating terminal numbers for the following:

    a. Engine generators.
    b. Transfer switches.
    c. Other load-control devices.
    d. Elevator controller in each elevator bank.

C. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

D. Delegated-Design Submittal: For paralleling low-voltage switchgear.

1. Include design calculations, signed and sealed by a qualified professional engineer, for selecting seismic restraints and for structural analysis of outdoor enclosures, including wind loading.

E. Sequence of Operation: Description of sequence of operation for paralleling controls in automatic, manual, system test, and peak-shaving modes.

1. Include the following in the description of the automatic-mode sequence of operation:

    a. Programmed sequence of initial generator starting and connection of generators to the isolated paralleling bus, including a description of how the proposed design complies with the requirements for redundancy.
    b. Programmed sequence of transferring loads to the isolated paralleling bus based on operator-adjustable preset priorities and preset loads. Include initial load settings.
    c. Programmed sequence of starting and stopping generators based on actual real-time measured loads.
    d. Programmed sequence of sending a load-shed signal to transfer switches when the generator frequency does not return to the normal frequency within the adjustable time period.
    e. Programmed sequence of stopping generators based on no transfer switch or other device sending a start signal.

2. Include the following in the description of the system testing mode sequence of operation:

    a. Load.
    b. No load.

3. Include in the description, the peak-shaving-mode sequence of operation.
4. Include in the description, the manual-mode sequence of operation showing that the manual mode fulfills the requirement to permit the operator at the paralleling low-voltage switchgear to accomplish all automatic, system test, and peak-shaving functions.
5. Paralleling Low-Voltage Switchgear Redundancy: Identify any single points of failure.

## 1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Floor plans showing dimensioned layout, required working clearances, and required area above and around paralleling low-voltage switchgear where pipe and ducts are prohibited.
2. Switchgear layout and relationships between components and adjacent structural and mechanical elements.
3. Support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Data: Certificates, for paralleling low-voltage switchgear, overcurrent protective devices, accessories, and components to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's special warranty.

## 1.6 CLOSEOUT SUBMITTALS

A. Updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

B. Operation and Maintenance Data: For paralleling low-voltage switchgear and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for sequence of operation.
b. Manufacturer's system checklists, maintenance schedule, and maintenance log sheets complying with NFPA 110.
c. Manufacturer's written instructions for testing and adjusting relays.
d. Time-current curves, including selectable ranges for each type of overcurrent protective device.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Control Power Fuses: six of each type and rating used. Include spares for the following:

a. Potential transformers.
b. Control power circuits.

2. Indicating Lights: six of each type installed.
3. Draw-out Circuit Breakers: One of each type and rating used for circuit breaker in the paralleling low-voltage switchgear.

B. Maintenance Tools: Furnish tools and miscellaneous items required for paralleling low-voltage switchgear test, inspection, maintenance, and operation. Include the following:

1. Traveling-type lifting device, rail mounted on top of paralleling low-voltage switchgear and all other items necessary to remove circuit breaker from housing and transport it to remote location.
2. Racking handle to move circuit breaker manually between connected and disconnected positions.

## 1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver paralleling low-voltage switchgear in sections of lengths that can be moved past obstructions in delivery path.

B. Store paralleling low-voltage switchgear indoors in clean dry space with uniform temperature to prevent condensation.

1.10 FIELD CONDITIONS

A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving paralleling low-voltage switchgear into place.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted and after approval from owner/CM.

C. Paralleling low-voltage switchgear assemblies are designed for application at rated continuous load current where altitude above sea level does not exceed 6600 feet (2011 m), ambient air temperature does not exceed 40 deg C, and effects of solar radiation do not need to be considered. For switchgear located outdoors, include expected humidity range and specify compliance with IEEE C37.24 if solar radiation is a factor.

D. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding [**104 deg F (40 deg C)**].

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace paralleling equipment that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for paralleling low-voltage switchgear, including clearances between paralleling switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. The multiple-generator paralleling monitoring and control panel in the paralleling low-voltage switchgear shall monitor and control the following standby power system components:

1. Paralleling low-voltage switchgear.
2. Single-generator monitoring and control system.
3. Single-generator paralleling monitoring and control systems that are part of the paralleling low-voltage switchgear] [located at each individual engine generator.
4. Engine generators.
5. Transfer switches.
6. Circuit breakers downstream of transfer switches.
7. Other load-control devices.
8. Distribution circuit breakers in paralleling low-voltage switchgear.

D. Redundant Standby Power System:

1. Single generator with associated single-generator paralleling monitoring and control system.
2. Black-start controller with no single point of failure.
3. Black-start controller with backup control in the multiple-generator paralleling monitoring and control system.
4. Multiple-generator paralleling monitoring and control system shall automatically be performed by a backup system without degradation in the event that primary system fails to function for any reason (such as component failure or off-line maintenance).
5. Multiple-generator paralleling monitoring and control system shall automatically be performed by a backup system without degradation in the event that primary system fails to function for any reason (such as component failure or off-line maintenance), except for the following manually operated functions:

    a. Load management.
    b. Peak shaving.

E. Sequence of Operation for Normal Conditions:

1. Paralleling low-voltage switchgear, including controlled generators**,** controlled circuit breakers, other controlled devices, and transfer switches, shall be in the automatic position and ready to operate on loss of power or other designated initiation conditions.
2. Each single-generator monitoring and control system has not received a "start" signal from the following:

    a. Transfer switch.
    b. Multiple-generator paralleling monitoring and control system.

F. Sequence of Operation for Loss of Normal Power Conditions:

1. Each single-generator monitoring and control system shall receive a start signal from a redundant system.

    a. Start signal may come from a transfer switch or other device directly wired to start each engine generator.

b. Start signal may come from the multiple-generator paralleling monitoring and control system that monitors loss of normal source availability from one or more transfer switches or other device.

2. On receiving a start signal, each single-generator monitoring and control system shall start engine generators and achieve rated voltage and frequency.
3. If engine generator fails to start, after expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
4. Transfer Inhibit Control: Multiple-generator paralleling monitoring and control system receives loss of normal source availability signal from transfer switch(es) **or other device** and sends transfer inhibit signals.

    a. Transfer switch(es) serving emergency loads shall not be sent a transfer-inhibit signal.
    b. Transfer switch(es) serving other than emergency loads that must transfer within a required time shall have the transfer-inhibit signal end at such a time as will permit transfer switch to operate within required time.
    c. Transfer switch(es) serving other than emergency loads that are not required to transfer within a required time shall be sent a transfer-inhibit signal.
    d. Transfer switch(es) serving loads that are to be disconnected after detecting loss of normal source availability shall signal the associated circuit breakers and other load devices to de-energize these predetermined loads.
    e. Transfer switch(es) serving HVAC loads that need to operate at a lower load by modifying the HVAC sequence of operation after detecting loss of normal source availability shall signal the DDC system for HVAC to change to the HVAC load-shed sequence of operation for the associated equipment.
    f. Transfer switch(es) serving elevator loads after detecting loss of normal source availability shall signal the associated elevator controllers that the elevators are connected to generator power and shall initiate the sequence of operation in the elevator control system to protect the elevators and to reduce elevator load demand.
    g. Distribution circuit breakers in the paralleling low-voltage switchgear, which are indicated in a priority-load schedule to transfer load by opening and closing the circuit breaker, receive an inhibit closing signal.

5. Black-Start Control: Prevent out-of-phase paralleling. After selecting the first generator to achieve 90 percent rated voltage and frequency, inhibit the connection of generator-controlled circuit breakers to the isolated paralleling bus, then close the circuit breaker connecting the first generator to the isolated paralleling bus.

    a. Comply with requirements in applicable engine generator Section for selection of the first engine generator to connect to the isolated paralleling bus.
    b. Redundant System: Multiple-generator paralleling monitoring and control system selects the first engine generator to connect to the isolated paralleling bus.

6. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-

voltage circuit breakers to the isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.

7. Failure of an Engine Generator to Synchronize: If engine generator fails to synchronize, sound an alarm after a preset time delay, but continue to attempt to synchronize the engine generator until signaled to stop by manual operation.

G. Priority Controller Sequence of Operation:

1. Programming from Human-Machine Interface for Priority Controller:

a. Set priority blocks of load that indicate priority number and scheduled size of load from the Priority-Load Schedule. Set generator blocks of capacity that indicate the individual engine generators and their capacity.
b. The signal to transfer loads to the engine generator source may be accomplished by one of the following:

1) Signaling to transfer-inhibit enable the transfer switch associated with the priority load to transfer the load.
2) Signaling the load-add relay at the transfer switch to transfer the priority load.
3) Closing the distribution-feeder circuit breaker associated with the priority load.
4) Enabling another device.

2. When generator has transferred Priority 1 emergency load, send signal to transfer loads that must be transferred within a specific time according to the Priority-Load Schedule.
3. When generator capacity is adequate to support next priority load, send signal to transfer next priority load to generator source until all priority loads have been transferred.

H. Overload Sequence of Operation:

1. Signal to shed loads from generator source may be accomplished by one of the following:

a. Signaling load-shed relay in a transfer switch associated with the priority load.
b. Opening distribution-feeder circuit breaker associated with the priority load.
c. Disabling another device.

2. Overload sequence of operation sends signal to shed lowest connected load priority when isolated paralleling bus frequency does not return to normal frequency within its adjustable time period.
3. If isolated paralleling bus does not return to normal frequency after shedding lowest connected priority load within adjustable time period, additional load continues to be shed by signaling to load shed in reverse priority until isolated paralleling bus returns to normal frequency.
4. Loads shed can be reconnected to isolated paralleling bus only by manual reset at human-machine interface.

I. Load-Demand Sequence of Operation:

1. With load-demand sequence of operation activated, controller continuously monitors total isolated paralleling bus load.
2. If isolated paralleling bus load is below preset limits and after a preset time delay, demand controller shuts down engine generators in predetermined order until minimum number of sets are operating. Set preset limits, predetermined order, and preset time delay, as well as choose manual operation, from human-machine interface.
3. On sensing available isolated paralleling bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.

J. Individual Transfer Switch Return to Normal Condition Sequence of Operation: Enable individual transfer switches to return to normal power when normal power is available at the transfer switch.

K. Feeder Circuit Breakers in Paralleling Low-Voltage Switchgear Return to Normal Condition Sequence of Operation: When normal power is available at transfer switches served by feeder circuit breaker, open circuit breaker.

L. Individual Circuit Breaker or Other Load Device for Loads Controlled Downstream from Transfer Switch Sequence of Operation: Return circuit breaker or other load device to closed position when transfer switch serving circuit breaker has returned to normal power.

M. Return to Normal Condition Sequence of Operation:

1. Process starts on removal of start signals from system.
2. When no load remains on isolated paralleling bus, all generator breakers open, go through cool-down period, and shut down.
3. If start signal is received during cool-down period, one engine generator is reconnected to isolated paralleling bus, and system operation follows that of "loss of normal power."

N. System Test Sequence of Operation:

1. Configure tests to comply with NFPA 110, Level 1 testing requirements for each generator. Automatically generate NFPA 110, Level 1 reports.
2. Single-generator test.
3. Multiple-generator test.
4. Start generators manually, by generator exerciser on user-defined schedule, or by remote contact from [**DDC system for HVAC**] [**SCADA system**].
5. Engine generator(s) start and achieve rated voltage and frequency.
6. Failure of Engine Generator to Start: After expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
7. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to the isolated

paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.

8. Failure of Engine Generator to Synchronize: If engine generator fails to synchronize, sound alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.
9. Manually select or automatically preselect whether test is a load or no-load test. If test is a load test, manually select or automatically preselect loads to be transferred according to schedule or by adjustable time delays at transfer switches. After generators are connected to isolated paralleling bus, transfer loads by sending signal to load-add relay that is connected to input for "remote transfer to generator source" of transfer switch controller or to other devices.[ **If test is load-bank test, automatically operate load-bank breaker to connect load bank for testing generators based on number and configuration of generators.**]
10. After adjustable period of time the system, allow engine generators to optimize down to only the required number to be online to avoid wet stacking. Set stopping and starting sequences through human-machine interface panel device and allow settings based on manual priorities or by engine run time.
11. On sensing available bus capacity diminished to set point, controller starts and closes engine generators to the isolated paralleling bus to accommodate load.
12. After system test is completed, transfer loads back to normal power with transfer switches. Shut down system using sequence in automatic mode.
13. If there is an outage during this mode of operation, automatically change to requirements specified in "Sequence of Operation for Loss of Normal Power Conditions" Paragraph, send load-shed signals to lower-priority loads until load is below generator capacity, signal any engine generator that is not currently operating to start, and cancel system test.

O. Peak-Shaving Sequence of Operation:

1. Start engine generators manually through human-machine interface or by remote contact initiated from a peak-shaving command from [**DDC system for HVAC**] [**SCADA system**].
2. Engine generator(s) start and achieve rated voltage and frequency.
3. Failure of Engine Generator to Start: After expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
4. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus.
5. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.
6. Failure of Engine Generator to Synchronize: If generator set fails to synchronize, sound an alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.
7. Through human-machine interface manually select or on closure of contact from the peak-shaving command preselected loads to be automatically transferred to isolated

paralleling bus. After engine generators are connected to isolated paralleling bus, transfer loads by sending signal to corresponding load-add relays that are connected to remote transfer to generator source control input at transfer switch or similar control devices. Add loads until contact closure from [**DDC system for HVAC**] [**SCADA system**] opens.

8. After adjustable period of time, allow engine generators to optimize down to only required number to be online to avoid wet stacking. Set stopping and starting sequences through the human-machine interface panel device and allow settings based on manual priorities or by engine run time.
9. If the isolated paralleling bus load is below preset limits and after preset time delay, demand controller shuts down engine generators in predetermined order until minimum number of sets are operating. Set preset limits, predetermined order, and preset time delay, as well as choose manual operation, from human-machine interface.
10. On sensing available isolated paralleling bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.
11. After peak shaving is completed, transfer loads back to normal power. Shut down system using sequence in automatic mode.
12. If there is an outage during this mode of operation, automatically change to requirements specified in "Sequence of Operation for Loss of Normal Power Conditions" Paragraph, send, send load-shed signals to lower-priority loads until load is below the engine generator capacity, signal generators that are not currently operating to start, and cancel system peak-shaving operation.
13. Manual Sequence of Operation: Include functions indicated for automatic mode, except that operator shall be able to monitor parameters and manually perform the operations.

P. Comply with NFPA 110 for the following:

1. Emergency: EPSS Level 1, Type 10.
2. Legally Required Standby: EPSS Level 1, Type 60.
3. Optional Standby: EPSS [**Level 1**] [**Level 2**], [**Type 10**] [**Type 60**] [**Type 120**] [**Manual**].

Q. Comply with NFPA 99 for healthcare applications.

## 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Paralleling low-voltage switchgear shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[ **and the unit will be fully operational after the seismic event**]."

B. Structural Performance: Paralleling low-voltage switchgear outdoor enclosures shall comply with locally adopted codes for gravity and wind loads.

2.3 MULTIPLE-GENERATOR PARALLELING MONITORING AND CONTROL SYSTEM

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for [**engine generator**] [**transfer switches**] [**transfer switches and engine generators**].

C. Components and Devices: Factory mounted in a [**metal-enclosed, paralleling low-voltage switchgear**] [**separate switchboard**].

1. Paralleling Low-Voltage Switchgear Door-Mounted Control Devices: Industrial, oil-type devices.
2. Indicator Lamps: High-intensity digital display.

D. Control Power for Multiple-Generator Monitoring and Control System: Supplied from 24-V dc starting batteries of engine generators.

1. Isolate each battery bank to prevent failure of one battery from disabling entire system.
2. Include, if necessary, separate control power battery system rated 24-V dc for equipment unable to accept voltage drop that occurs during engine cranking.

E. Redundant Multiple-Generator Monitoring and Control System Controller:

1. Fully equip with hot swappable programmable logic controller, power supplies, and I/O points.
2. Black-start control equipment specified in applicable engine generator Section.

F. Multiple-generator monitoring and control system auto/manual selector switch.

G. Control switch for circuit breaker that serves load bank.

H. Full-Color, Touch-Screen, Human-Machine Interface Device:

1. Minimum viewing area of [**60 sq. in. (387 sq. cm)**] [**100 sq. in. (645 sq. cm)**] shall be configurable in either U.S. standard or SI (metric) units.
2. Main Menu: Include date, time, and system status messages. Configure screens so that no screen is more than three touches from any other screen.

a. Individual engine generator data shall be accessed at the paralleling low-voltage switchgear from the [**main menu**] [**main menu and each single-generator paralleling monitoring and control system**].

3. One-Line Diagram: Depicting system configuration and system status by screen animation, screen colors, text messages, or pop-up indicators.

a. Conditions for Engine Generators, Buses, and Paralleling Circuit Breakers: Energized or de-energized.
b. Engine Generator Modes:

1) Auto.
2) Lockout.
3) Reset.
4) Off.
5) Cool down.
6) Test off line.
7) Test on load.

c. Engine Generator Status: Normal, warning, shutdown, or load-demand stop.
d. Paralleling Circuit-Breaker Status: Open, closed, or tripped.
e. Bus Conditions: Energized or de-energized.
f. Percent load.

4. AC metering screen for isolated paralleling bus shall display the following:

a. Phase, volts, and amperes.
b. Kilowatts.
c. Kilovolt amperes.
d. Kilovolt-ampere rating.
e. Power factor.
f. Frequency.
g. Kilowatt hour.
h. Kilowatt demand.
i. Real-time trend chart for system kilowatts and volts updated on not less than one-second intervals.
j. A minimum of one historical trend chart for total system loads with intervals no shorter than five minutes and a minimum duration of four hours.
k. Percent of available capacity of the engine generators that are operating in parallel on the bus.

5. Engine Generator Monitoring and Control Screen:

a. Control:

1) Engine generator manual start/stop control (functional only when the paralleling low-voltage switchgear mounted control switch is in "Auto" position).
2) Engine generator alarm reset.
3) Manual paralleling and circuit-breaker enable/inhibit controls.
4) Engine function and timer settings.
5) System function, testing, and timer settings.
6) Engine generator optimization settings: automatically determine the priority of the engine generators based on engine run time and number of engine starts or manually assign engine priorities.

b. Status and Alarms:

1) Power Metering: Watts, volt-ampere reactive, power factor, frequency, amperes, and voltage.
2) Engine run hours.
3) Engine status.
4) Number of generator circuit-breaker operations.
5) Replicate status and alarms from each single-generator paralleling monitoring and control panel.

6. Dual, Three-Phase, Metering Screen: Graphical analog (270 electrical degree) metering representation with digital display. Display two generators at the same time or one generator and the isolated paralleling bus at the same time. Display graphical synchroscope when one generator and the isolated paralleling bus are selected.

   a. True rms, three-phase voltage, amperes, kilowatts, kilovolt amperes, kilovolt-ampere reactive, power factor, and frequency parameters.
   b. Engine battery voltage display.

7. Password-Protected System Control Screen:

   a. System Test Modes: Test with load/test without load/normal/retransfer time-delay override.
   b. Test with Load: Starts and synchronizes engine generators on isolated paralleling bus; all loads are transferred to the isolated paralleling bus.
   c. Test without Load: Starts and synchronizes engine generators on isolated paralleling bus but does not transfer loads to the isolated paralleling bus.
   d. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.

8. Password-Protected, Peak-Shaving Control Screen:

   a. Peak-Shaving Modes: Manual start and transfer of loads; automatic start and transfer of loads by DDC system for HVAC peak-shaving relay closure.
   b. For automatic mode, set load priorities for peak-shaving function.
   c. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.

9. Load-Demand Control Screen: Monitors total load on the isolated paralleling bus and controls number of engine generators running so that capacity tracks load demand.

   a. Load-Demand Control: Enable/disable.
   b. Set engine generator shutdown sequence.
   c. Load-Demand Pickup Set Point: Adjustable from 90 to 40 percent in 5 percent increments.
   d. Load-Demand Dropout Set Point: Adjustable from 20 to 70 percent in 5 percent increments.

10. Manual Load Control Screen: Allows operator to manually add or delete engine generators from paralleled system in response to system load parameters.

a. Indication of system available in kilowatts and amperes.
b. Control functions allow manual addition/removal of engine generators on system, and activation of load-shed/load-restore functions.

11. Load-Add/Load-Shed Sequence Screen: Password protected and with the following minimum functions:

a. Display sequence.
b. Assigns "load-add sequence priority" to each load-control relay with designation for relay operation after a set number of engine generators are online.
c. Assigns "load-shed sequence priority" to each load-control relay with designation for relay operation depending on number of engine generators online.

12. Alarm Summary and Run Report Screen:

a. Lists most recent alarm conditions and status changes.
b. Lists a minimum of the most recent 32 alarm conditions by name and time/date; acknowledges alarm conditions with time/date.
c. For each start signal, lists start time and date, stop time and date, maximum kilowatt and ampere load on system during run time, and start and stop times of individual engine generators.
d. Lists generator circuit position and status.
e. Access to trend all monitored automatic transfer switches.
f. [**16-gigabyte**] <**Insert value**> hard-disk space for storing the database file for multiple-generator paralleling monitoring and control panel trending and event logging. Trend and log data at a resolution of one second. If hard drive is full, overwrite in a first-in-first-out procedure.

1) Trend up to eight monitored points simultaneously.

13. Load Status and Control Screen: Displays status of automatic transfer switches connected to the system for [**32**] [**64**] transfer switches, and other controlled devices.

a. Automatic transfer switch connected to normal.
b. Automatic transfer switch connected to emergency.
c. Controlled circuit breakers downstream from the automatic transfer switch device enabled or disabled.
d. Engine start indication.
e. Load-shed indication.
f. Load-add indication.
g. Inhibit to emergency source.
h. Inhibit to normal source.
i. Transfer Switch Power Metering Function: Total kilowatt, three-phase current, and three-phase voltage.
j. Automatic Transfer Switch Load Priority: Ability to change priorities of automatic transfer switches (password protected).
k. Display name, status, and priority of each load block (whether on or off) and the total load of that block.

l. Allow for manually adding or shedding loads.

14. Automated email messages shall be transmitted when shutdowns occur and shall include time and date of alarm.
15. Based on either the number operations or the time since the last maintenance, suggest maintenance period for generator (run hours), controlled circuit breaker (number of operations), and transfer switches (number of transfers).
16. Status and Alarm Screen:

    a. Visual alarm status indicator and alarm horn with silence and acknowledge push button.
    b. Status, Light Only:

        1) "SYSTEM NOT IN AUTO" (red).
        2) Running Status: Display engine generator number and running-status light (green).
        3) Load-demand mode (green).
        4) Priority Load Status: Display load number with "LOAD ADD" (green) and "LOAD SHED" (red).
        5) System test (green).
        6) Remote system start (red).
        7) Monitoring of Each Transfer Switch:

            a) Normal source available for each (green).
            b) Connected to normal (green).
            c) Generator source available (green).
            d) Connected to generator source (green).

    c. Status Light and Alarm:

        1) Isolated paralleling bus under frequency (red).
        2) Isolated paralleling bus over frequency (red).
        3) Auxiliary power failure (red).
        4) Emergency start signal power failure (red).
        5) Load-Shed Level Status: Displays load number and red load-shed, status light.
        6) Generator Alarm Status: Displays generator number and red "Check Generator" status light.
        7) Controller malfunction (red).
        8) Check station battery (red).
        9) Isolated paralleling bus overload (red).
        10) System not in auto (red).
        11) Main tank, low fuel (amber)
        12) Main tank, high fuel (amber).
        13) Main tank, fuel leak (red).

l. Remote Monitoring: Replicate human-machine interface monitoring functions [**at SCADA**] [**at remote computer terminal**] [**via communication bus**].

J. Remote Monitoring of Status and Alarms: Replicate human-machine interface status and alarms at DDC system for HVAC via isolated contacts.

## 2.4 SINGLE-GENERATOR PARALLELING MONITORING AND CONTROL SYSTEM

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for [**engine generator**] [**transfer switches**] [**transfer switches and engine generators**].

C. Components and Devices: Factory mount in each single-generator section of the metal-enclosed, paralleling low-voltage switchgear.

1. Paralleling low-voltage switchgear door-mounted control devices shall be industrial oil-type devices. Indicator lamps shall be high-intensity digital display.

D. Control Power: Supply control power from the 24-V dc starting batteries from the controlled generator. Include separate control power battery system rated 24-V dc for any equipment unable to accept the voltage drop that occurs during engine cranking.

E. Programmable Logic Controller: Factory-mounted controller, separate from the multiple-generator paralleling monitoring and control system in each single-generator paralleling monitoring and control module of the metal-enclosed, paralleling low-voltage switchgear.

F. Single-Generator Paralleling Low-Voltage Switchgear Circuit Breaker:

1. Factory mount the circuit-breaker control switch.
2. Paralleling Circuit-Breaker Monitor and Control:

a. Monitors circuit-breaker auxiliary contacts.
b. Initiates fault signal if circuit breaker fails to close within adjustable time-delay period (0.5 to 15 seconds).
c. Trips open and locks out paralleling circuit breaker on paralleling circuit breaker failure to close, until manually reset.

G. Generator Mode Selector Switch: Factory mounted in the single-generator paralleling monitoring and control system module of the metal-enclosed, paralleling low-voltage switchgear.

1. "Lockout/Reset" mode prevents generator from starting or immediately shuts down generator if running.
2. "Off/Cool-Down" mode stops engine after a cool-down period.
3. "Auto" mode allows generator to start on receipt of remote start signal. If the generator is already running and there is not a start signal, then "Auto" mode allows engine to run for predetermined cool-down period before stopping.
4. "Test Off-Line" allows engine to start and run as if a start signal were received, except it does not allow generator to connect to the isolated paralleling bus unless a start signal is received.

5. "Test Online" allows the engine to start, run, and connect to the isolated paralleling bus as if a start signal were received.

H. Engine Generator Controller: Woodward compatible.

1. Factory mount governor (speed control and load sharing) supplied in applicable engine generator Section in single-generator monitoring and control module.
2. Loading control interface to the governor system.
3. Automatic synchronizer.

I. Automatic Synchronizer:

1. Include sync mode selector switch with RUN-OFF-CHECK-PERMISSIVE positions. In RUN mode, enable active synchronization and sync-check function. In CHECK mode, perform the sync-check function. In PERMISSIVE mode, annunciate when generator and bus are synchronized but do not allow breaker closure.

    a. Include discrete inputs in synchronizer to switch to each mode.

2. Bias the generator speed and voltage to match the paralleling isolated bus.
3. If the automatic synchronizer receives a permissive signal to allow closure to the paralleling isolated bus and the generator is within synchronizing limits, send a close signal to the single-generator paralleling circuit breaker.

J. Sync-switch, removable, keyed T-handle.

K. "Engine Generator Synchronized" Indication: Indicator lamp or digital-display indication of synchronization.

L. Voltage and Frequency Raise and Lower Switches: Allow plus or minus 5 percent adjustment when engine generator is operating but is not connected to the isolated paralleling bus.

M. Control and Reset Push Button: Have flashing lamp to indicate generator is locked out due to fault condition.

N. Lamp Test Push Button: Simultaneously tests all lamps on panel.

O. Control Panel Illumination: DC lamps illuminate panel when lighting from surrounding environment is unavailable.

P. Emergency Stop Push Button: Red mushroom-head switch maintains its position until manually reset.

Q. Alarm and Status Indicating Display:

1. Status and Alarm Indications:

    a. Status, Light Only (Nonlatching):

1) Generator mode selector switch not in auto (red).
2) Generator mode selector switch in auto (green).
3) Start signal received (green).
4) Emergency stop activated (red).
5) Demand mode standby (green).
6) Timing for start (green).
7) Timing for shutdown (green).
8) Generator circuit breaker closed (red).
9) Generator circuit breaker open (green).

    a) Generator circuit breaker locked out (white).
    b) Generator circuit breaker racked out (white)

10) Remote generator breaker is open (red).
11) Engine stopped (green).
12) Time-delay start (green).
13) Engine running (red).
14) Engine cool-down (green).

b. Pre-Alarm, Light and Horn (Nonlatching):

1) Pre-high coolant temperature (amber).
2) Pre-low oil pressure (amber).
3) Low coolant temperature (amber).
4) Engine low battery (amber).
5) Battery charger failure (amber).
6) Auxiliary power failure (amber).
7) Low fuel-day tank (amber).
8) Paralleling low-voltage switchgear generator breaker failed to close (amber).
9) Paralleling low-voltage switchgear generator breaker failed to open (amber).
10) Overcurrent alarm (amber).
11) Day tank low-fuel alarm (amber).
12) Ground-fault alarm (amber).

c. Shutdown Alarm, Light and Horn (Latching):

1) Engine overcrank (red).
2) Engine overspeed (red).
3) Engine low oil pressure (red).
4) Engine high coolant temperature (red).
5) Engine low coolant level (red).
6) Engine remote emergency shutdown (red).
7) Generator fail to synchronize shutdown (red).
8) Generator circuit breaker tripped (red).
9) Generator circuit breaker failure (red).
10) Generator not in auto (red).

11) Generator loss of field (red).
12) Generator reverse power (red).
13) Generator undervoltage (red).
14) Generator overvoltage (red).
15) Generator underfrequency (red).
16) Generator overfrequency (red).
17) Phase rotation (red).
18) Generator short circuit (red)
19) Day tank low-fuel shutdown (red).
20) Air damper activated, shutdown (red).

R. Paralleling Controls and Protection:

1. Engine Generator Governor (Speed Control and Load Sharing): Comply with requirements in applicable engine generator Section. Components shall be Woodward compatible.
2. Kilowatt Load Sharing Control and Interface:

   a. Operates engine generator governors during synchronizing and provides isochronous load sharing when paralleled.
   b. Allows engine generator to ramp up to kilowatt load level[ **signaled by multiple-generator monitoring and control controller**].

3. Load-Demand Governing Control:

   a. Causes engine generator to ramp down at an operator-adjustable rate to zero load when signaled to shut down in load-demand mode.
   b. Causes engine generator to ramp up at an operator-adjustable rate to a proportional share of total isolated paralleling bus load when signaled to restart.

4. Kilovolt-Ampere-Reactive Load Sharing Control:

   a. Operates alternator excitation system while engine generator is paralleled.
   b. Causes sharing of reactive load among engine generators to within 1 percent of equal levels without voltage drop.

5. Paralleling Monitor and Control:

   a. Monitors and verifies that engine generator has reached 90 percent of nominal voltage and frequency before closing to the isolated paralleling bus.
   b. Prevents accidental closure of the breaker with the engine generator out of phase with the bus.
   c. Prevents out-of-phase closure to the isolated paralleling bus due to errant manual or automatic operation of synchronizer.
   d. System of diagnostic digital displays to assist in analyzing synchronization.

6. Synchronizer Control:

a. Adjusts engine governor to match voltage, frequency, and phase angle of the isolated paralleling bus.
b. Maintains engine generator voltage within 1 percent of the isolated paralleling bus voltage, and phase angle within 20 electrical degrees of the isolated paralleling bus for 0.5 seconds before circuit-breaker closing.
c. Provides "fail-to-synchronize time delay" adjustable from 10 to 120 seconds; with field selectivity to either initiate alarm or shut down engine generator on failure condition.

7. Reverse Power Monitor and Control:

a. Prevents sustained reverse power flow in engine generator.
b. Trips generator paralleling circuit breaker and initiates engine generator shutdown when reverse power condition exceeds 10 percent of engine generator kilowatt for three seconds.
c. Trips generator paralleling circuit breaker and initiates engine generator shutdown when reverse kilovolt-ampere conditions exceeds 20 percent of generator kilovolt-ampere rating.

8. Phase Rotation Monitor and Control: Verifies engine generator and isolated paralleling bus phase rotation match prior to closing paralleling circuit breaker.
9. Electronic Alternator Overcurrent Alarm and Shutdown Control:

a. Monitors current flow at engine generator output terminals.
b. Initiates alarm when load current on engine generator is more than 110 percent of rated current for more than 60 seconds.
c. Overcurrent shutdown function matched to thermal damage curve of alternator.

10. Electronic Alternator Short-Circuit Protection: Shuts down generator, without instantaneous-trip function, when load current is more than 175 percent of rated current and combined time/current approaches thermal damage curve of alternator.
11. Loss of Excitation Monitor: Displays alarm on single-generator paralleling monitoring and control panel when generator controls sense loss of excitation to alternator while paralleled to the isolated paralleling bus.
12. Cool-Down, Time-Delay Control: Adjustable, zero to 600 seconds.
13. Start Time-Delay Control: Adjustable, zero to 300 seconds.
14. Frequency Control: Initiate an alarm condition when engine generator is below 90 percent of rated frequency for more than 20 seconds or is over the frequency.
15. Under- and Overvoltage Control: Initiate an alarm condition when the engine generator is at 90 percent voltage for more than 20 seconds or is over the voltage.

## 2.5 METAL-ENCLOSED, CIRCUIT-BREAKER SWITCHGEAR (600 V AND LESS)

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for [**engine generator**] [**transfer switches**] [**transfer switches and engine generators**].

C. Description: Factory assembled and tested, and complying with IEEE C37.20.1 and UL 1558.

D. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded neutral system.

E. Nominal System Voltage: [**480 V, three**] [**480/277 V, four**] [**240 V, three**] [**208/120 V, four**] wire, 60 Hz.

F. Isolated Paralleling Bus: [**5000**] [**4000**] [**3200**] [**2000**] [**1600**] <**Insert value**> A.

1. Phase-, Neutral-, and Ground-Bus Materials:

a. Phase[ **and Neutral**] Bus: [**Copper, silver plated at connection points**] [**Copper, tin plated**] [**Aluminum, tin plated**].
b. Ground Bus: Copper[**, silver**] [**, tin**] plated; minimum size 1/4 by 2 inches (6 by 50 mm).

2. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

a. Uniform capacity for horizontal and vertical bus.
b. Neutral Bus: [**50**] [**100**] percent of phase-bus ampacity, except as indicated. [**Equip bus with pressure-connector terminations for outgoing neutral conductors**] [**Include braces for neutral-bus extensions for busway feeders**].
c. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.

G. Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

H. Switchgear Fabrication:

1. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
2. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
3. Auxiliary Compartments: Match and align with basic switchgear assembly.

a. Bus transition sections.
b. Pull sections.
c. Hinged front panels for access to accessory and blank compartments.
d. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers; and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.

1) Set pull box back from front to clear circuit-breaker lifting mechanism.
2) Bottom: Insulating, fire-resistive material with separate holes for cable drops into switchgear.
3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.

e. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
f. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
g. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.

1) Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

4. Circuit-Breaker Terminals for Cable Connections: Silver-plated copper bus extensions equipped with pressure connectors for conductors.

I. Circuit Breakers: Comply with IEEE C37.13, IEEE C37.16, and IEEE C37.17.

1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

a. Normal Closing Speed: Independent of both control and operator.
b. Slow Closing Speed: Optional with operator for inspection and adjustment.

3. Stored-Energy Mechanism: Electrically charged, with optional manual charging[ **and operation counter**].
4. Trip Devices:

a. Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, and a release mechanism.
b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
c. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
d. Time-Current Characteristics: Field adjustable.
e. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
f. Long-Time- and Short-Time-Delay Functions: Three bands, minimum; marked "minimum," "intermediate," and "maximum."
g. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
h. Pickup Points: Five minimum, for instantaneous-trip functions.
i. Ground-fault protection[ **alarm**] with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

1) Three-wire circuit or system.
2) Four-wire circuit or system.

3) Four-wire, double-ended substation.

j. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

5. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
6. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions.

a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
b. Circuit-Breaker Positioning:

1) An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield.
2) An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open.
3) Status for connection devices for different positions includes the following:

a) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
b) Disconnected Position: Primary and secondary devices and ground contact disengaged.

7. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position; arranged to permit inspection of contacts without removing circuit breaker from switchgear.
8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
9. Operating Handle: One for each circuit breaker capable of manual operation.

a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with the isolated paralleling bus.

10. Electric Close Button: One for each electrically operated circuit breaker.

a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with the isolated paralleling bus.

11. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

12. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
13. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.
14. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.
15. Shunt-Trip Devices:

    a. 24-V dc for generator paralleling circuit breakers and for distribution paralleling switchgear circuit breakers.
    b. Where indicated.

16. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

J. Metering:

1. Type and Locations:

    a. Isolated Paralleling Bus: [**Multifunction digital-metering monitor;**] [**Analog metering for voltage, amperage, frequency, watt-hour, and recording demand;**] on door of separate metering compartment.
    b. Generator Circuit Breakers: [**Multifunction digital-metering monitor;**] [**Analog metering for voltage, amperage, frequency, watt-hour, and recording demand;**] on circuit-breaker door.
    c. Distribution Circuit Breakers: [**Multifunction digital-metering monitor;**] [**Analog metering for voltage, amperage, frequency, watt-hour, and recording demand;**] on circuit-breaker door.

2. Instrument Transformers:

    a. Comply with IEEE C57.13.
    b. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
    c. Current Transformers:

        1) Burden and accuracy class suitable for connected relays, meters, and instruments.
        2) Size for the maximum momentary current amperage based on calculation or the momentary rating of the circuit breaker protecting the conductor.
        3) Include shorting-type terminal blocks.

3. Multifunction Digital-Metering Monitor:

    a. Microprocessor-based unit suitable for three- or four-wire systems.
    b. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
    c. Switch-selectable digital display with the following features:

        1) Phase Currents, Each Phase: Plus or minus 1 percent.
        2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.

3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
4) Three-Phase Real Power: Plus or minus 2 percent.
5) Three-Phase Reactive Power: Plus or minus 2 percent.
6) Power Factor: Plus or minus 2 percent.
7) Frequency: Plus or minus 0.5 percent.
8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

d. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
e. Mounting: Display and control unit that is flush or semirecessed mounted in instrument compartment door.

4. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, accurate within 1 percent of full scale range; semirecessed mounting, with antiparallax 250-degree scale and external adjustment.

a. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
b. Voltmeter Selector Switch: Rotary type with off position; provides readings of phase-to-phase[ **and phase-to-neutral**] voltages.
c. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
d. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
e. Watt-Hour Meters: Flush- or semirecessed-mounting type, [**5 A, 120 V, three phase, three wire; with three elements**] <**Insert characteristics**>, [**15-minute**] <**Insert value**> indicating demand register, and provision for testing and adding pulse initiation.
f. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with [**15-minute**] <**Insert value**> interval.

1) Operation: Counts and records a succession of pulses entering two channels.
2) Housing: Drawout type, back-connected case arranged for semirecessed mounting.

K. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.

1. Functions: <**Insert functions**>.
2. Characteristics: <**Insert characteristics**>.

L. Door-Mounted Control Components: Industrial-type oiltight devices and digital-display indicator lamps.

M. Control Power Supply:

1. Control power transformer shall supply 120-V ac control circuits from the generator source through secondary disconnect devices.
2. Include a control power transformer for each generator paralleling switchgear circuit breaker connected to the generator side of the circuit breaker.
3. Include a control power transformer for each distribution paralleling switchgear circuit breaker.
4. Dry-type transformers shall be in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
5. Two control power transformers in separate compartments with necessary interlocking relays; each transformer shall be connected to line side of associated main circuit breaker.

    a. Secondary windings shall be connected through relay(s) to control bus to effect an automatic transfer scheme.
    b. Secondary windings shall be connected through an internal automatic transfer switch to paralleling switchgear control power bus.

6. Control Power Fuses: Primary and secondary fuses shall provide current-limiting and overload protection.

N. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
3. Conductors shall be sized according to NFPA 70 for duty required.

O. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

P. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems" for electrical identification devices and installation.

1. Identify units, devices, controls, and wiring.
2. Mimic Bus: Continuous mimic bus, applied to front of paralleling low-voltage switchgear, arranged in one-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

    a. Mimic-bus segments coordinated with devices in paralleling low-voltage switchgear sections to which applied, to produce a concise visual presentation of principal paralleling switchgear components and connections.
    b. Medium: Painted graphics, as selected by Architect.
    c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

Q. Indoor Enclosure Material: Steel.

R. Outdoor Enclosure Fabrication Requirements: Galvanized steel, weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating.

1. Features for Each Compartment or Group of Compartments:

    a. Thermostatically controlled air-conditioning units sized to prevent temperatures exceeding [**80 deg F (27 deg C)**] <**Insert temperature**>.
    b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
    c. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
    d. Hinged front door with locking provisions.
    e. Interior light with switch.
    f. Weatherproof ground-fault circuit-interrupter duplex receptacle.
    g. Power for air conditioning, heaters, lights, and receptacles to be provided from control power transformer.

2. Features for Weatherproof Internal Aisle Construction:

    a. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
    b. Aisle access doors with exterior padlocking provisions and interior panic latches.
    c. Thermostatically controlled aisle space heaters operating at one-half or less of rated voltage.
    d. Thermostatically controlled, aisle air-conditioning units sized to prevent temperatures exceeding 104 deg F (40 deg C).
    e. Vaporproof, fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
    f. At least two duplex, ground-fault circuit-interrupter receptacles, located in aisle.
    g. Aisle ventilation louvers arranged with makeup air near the floor level and exhaust air near the roof level.

        1) Louvers shall have insect and rodent screen and filter, arranged to permit air circulation while excluding insects, rodents, and exterior dust.
        2) Exhaust fans.

S. Access: Fabricate enclosure with hinged, rear cover panels to allow access to rear interior of paralleling low-voltage switchgear.

T. Finish: Manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

U. Accessories:

1. Tools for circuit-breaker and switchgear tests, inspections, maintenance, and operation.
2. Racking handle to manually move circuit breaker between connected and disconnected positions.
3. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
4. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

V. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

W. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of draw-out circuit breaker installed.

X. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

Y. Storage for Manual: Rack or holder, near the operating instructions, for a copy of maintenance manual.

## 2.6 IDENTIFICATION

A. Compartment Nameplates: [**Engraved, laminated acrylic**] [**Engraved, melamine plastic**] [**Preprinted aluminum**], as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Medium: Painted graphics, as selected by Architect.
3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

C. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.

7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

## 2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect paralleling low-voltage switchgear, with [**generators**] [**generators and transfer switches**], at paralleling low-voltage switchgear manufacturer's factory.

1. Paralleling Low-Voltage Switchgear:

a. NETA ATS, 7.6.1.2, "Circuit Breaker, Air, Low-Voltage Power Switchgear."
b. Factory test with simulated inputs. Test control and relay functions for proper operation.

2. Engine Generator:

a. NETA ATS, 7.22.1, "Emergency Systems, Engine Generator."
b. NETA ATS, 7.15.1, "Rotating Machinery, AC Motors & Generator."

3. Automatic Transfer Switches:

a. NETA ATS, 7.22.3, "Emergency System, Automatic Transfer Switches."

B. Verification of Performance: Rate paralleling low-voltage switchgear, with [**generators**] [**generators and transfer switches**], according to operation of functions and features specified.

C. Paralleling low-voltage switchgear, with [**generators**] [**generators and transfer switches**], will be considered defective if it does not pass tests and inspections.

D. Coordinate scheduling of the factory witness test with Architect[ **and Owner**]. Perform successfully tests prior to witness test.

E. Prepare test and inspection reports.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, where paralleling low-voltage switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance of the Work.

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

## 3.2 INSTALLATION

A. Comply with NECA 1 and applicable portions in NECA 400.

B. Equipment Mounting:

1. Install paralleling low-voltage switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from paralleling low-voltage switchgear units and components.

## 3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."

B. Diagrams and Instructions:

1. Frame and mount under clear acrylic plastic on front of paralleling low-voltage switchgear.

a. Operating Instructions: Printed basic instructions for paralleling low-voltage switchgear, including control and key-interlock sequences and emergency procedures.
b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

## 3.4 CONNECTIONS

A. Comply with grounding and bonding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Comply with wire and cable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## 3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.
3. Inspect paralleling switchgear installation, including wiring, components, connections, and equipment.[ **Test and adjust components and equipment.**]
4. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing.
5. Complete installation and startup checks according to manufacturer's written instructions.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

E. Perform tests and inspections[ **with the assistance of a factory-authorized service representative**].

F. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

    a. AC generators and emergency systems.
    b. Switchgear.
    c. Circuit breakers.
    d. Instrument transformers.
    e. Metering and instrumentation.
    f. Ground-fault systems.
    g. Battery systems.
    h. Surge arresters.
    i. Capacitors.

2. Perform NFPA 100 tests for Type 1 essential power systems.

G. Paralleling low-voltage switchgear will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

J. Test sequence of operation step by step for each mode.

## 3.6 ADJUSTING

A. Set field-adjustable, electronic circuit-breaker trip characteristics according to results specified in Section 260573.16 "Coordination Studies."

B. Set field-adjustable, electronic circuit-breaker trip characteristics.

## 3.7 CLEANING

A. On completion of installation, inspect interior and exterior of paralleling low-voltage switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

## 3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to paralleling low-voltage switchgear, according to manufacturer's written instructions, throughout periods when paralleling switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

## 3.9 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain paralleling low-voltage switchgear.

END OF SECTION 262313

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# SECTION 262413 - SWITCHBOARDS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Disconnecting and overcurrent protective devices.
3. Accessory components and features.
4. Identification.

B. Related Requirements

1. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Delegated Design Submittal:

1. For arc-flash hazard analysis.
2. For arc-flash labels.

## 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

## 1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NECA 400.

1.9 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F.
b. Altitude: Not exceeding 6600 feet.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 SWITCHBOARDS

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

1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

G. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

H. Nominal System Voltage: 480Y/277 V.

I. Main-Bus Continuous: 4000 A.

J. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

K. Indoor Enclosures: Steel, NEMA 250, Type 1.

L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

M. Barriers: Between adjacent switchboard sections.

N. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

O. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

R. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Copper feeder circuit-breaker line connections.
4. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

U. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long and short time adjustments.
      d. Ground-fault pickup level, time delay, and I squared t response.

   4. MCCB Features and Accessories:

      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard.

2.5 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400.

   1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
   2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
   3. Protect from moisture, dust, dirt, and debris during storage and installation.
   4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

## 3.2 INSTALLATION

A. Install switchboards and accessories according to NECA 400.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Comply with NECA 1.

## 3.3 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

## 3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

## 3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

1. Acceptance Testing:

a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.

b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.

3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

5. Perform the following infrared scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

## 3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

## 3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

## 3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

## 3.9 END OF SECTION 262413

# SECTION 262416 - PANELBOARDS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

### 1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. MCCB: Molded-case circuit breaker.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.

6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

## 1.5 INFORMATIONAL SUBMITTALS

A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.

## 1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

## 1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
b. Altitude: Not exceeding 6600 feet.

1.11 WARRANTY

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

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Height: 84 inches maximum.

3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
4. Finishes:

    a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Same finish as panels and trim.

F. Incoming Mains:

1. Location: Top or Bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.

    a. Plating shall run entire length of bus.
    b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

I. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

## 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

## 2.3 POWER PANELBOARDS

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

## 2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only (Refer to Electrical Drawings – One-Line Diagram, Panelboard Schedules).

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

## 2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
4. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
5. Subfeed Circuit Breakers: Vertically mounted.
6. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Breaker handle indicates tripped status.
    c. UL listed for reverse connection without restrictive line or load ratings.
    d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
    e. Application Listing: Appropriate for application.
    f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
    h. Multipole units enclosed in a single housing with a single handle.
    i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
    j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

## 2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:

1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports 1-1/4 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub three (3) 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

## 3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

## 3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
2. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

## 3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

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# SECTION 262500 - ENCLOSED BUS ASSEMBLIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Feeder-bus assemblies.
2. Plug-in bus assemblies.
3. Bus plug-in devices.

### 1.3 DEFINITIONS

A. kAIC: kiloampere interrupting capacity.

B. SPD: Surge protective device.

### 1.4 ACTION SUBMITTALS

A. Shop Drawings: For each type of product.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
2. Show fittings, materials, fabrication, and installation methods for listed firestop barriers.
3. Indicate required clearances, method of field assembly, and location and size of each field connection.
4. Detail connections to switchgear, switchboards, transformers, and panelboards.
5. Cable and conductor terminal sizes for bus and plug-in device terminations.
6. Wiring Diagrams: Power wiring.

B. Delegated-Design Submittal: For seismic-restraint details, signed and sealed by a qualified professional engineer.

1. Include design calculations for selecting seismic restraints.
2. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
2. Clearances for access above and to the side of enclosed bus assemblies.
3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
4. Support locations, type of support, and weight on each support.
5. Location of adjacent construction elements including luminaires, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For enclosed bus assemblies, plug-in devices, accessories, and components.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Plug-in Units: 10 percent of amount installed for each size indicated, but no fewer than one unit.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less."

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices from single source from single manufacturer.

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

C. Comply with UL 857.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design enclosed bus assemblies, plug-in devices, and components.

B. Seismic Performance: Enclosed bus assemblies, plug-in devices, and components shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: [**1.5**] [**1.0**].

C. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding [**122 deg F (50 deg C)**] [**140 deg F (60 deg C)**] <**Insert ambient temperature**>.

2.3 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces

defined in Section 260548.16 "Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure

3. Electrical Characteristics:

    a. Voltage: [**120/208**] [**240**] [**480**] [**277/480**] V.
    b. Phase: Three; [**3 wire**] [**4 wire**].
    c. Percent of Neutral Capacity: [**50**] [**100**] [**200**] <**Insert value**>.

4. Short-Circuit Interrupting Rating:

    a. For Bus Amperage of 800: 85 symmetrical kAIC.
    b. For Bus Amperage of 1200: 100 symmetrical kAIC.
    c. For Bus Amperage of 1600: 125 symmetrical kAIC.
    d. For Bus Amperage of 2500: 150 symmetrical kAIC.
    e. For Bus Amperage of 5000: 200 symmetrical kAIC.

5. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
6. Bus Materials: Current-carrying [**copper**] [**aluminum**] conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
7. Voltage Drop:

    a. Measure voltage drop at 30 deg C ambient with bus thermally stabilized at full rated load.
    b. Three-phase, line-to-line voltage drop less than 3.1 V per 100 feet (30.5 m) at 40 percent power factor.

8. Ground: 50 percent capacity, integral with housing.
9. Ground: 50 percent capacity, internal bus bar of material matching bus material.
10. Ground: 50 percent capacity, isolated, internal bus bar of material matching bus material.
11. Enclosure: [**Steel**] [**Aluminum**], with manufacturer's standard finish.[ **Weatherproof, sealed seams, drains, and removable closures.**]
12. Fittings and Accessories: Manufacturer's standard.
13. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
14. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs and up to 16 feet (5 m) for vertically mounted runs.
15. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

B. Plug-in Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Electrical Characteristics:

a. Voltage: [**120/208**] [**240**] [**480**] [**277/480**] V.
b. Phase: Three; [**3 wire**] [**4 wire**].
c. Percent of Neutral Capacity: [**100**] [**200**] <**Insert value**>.

3. Short-Circuit Interrupting Rating:

a. For Bus Amperage of 800: 85 symmetrical kAIC.
b. For Bus Amperage of 1200: 100 symmetrical kAIC.
c. For Bus Amperage of 1600: 125 symmetrical kAIC.
d. For Bus Amperage of 2500: 150 symmetrical kAIC.
e. For Bus Amperage of 5000: 200 symmetrical kAIC.

4. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
5. Bus Materials: Current-carrying [**copper**] [**aluminum**] conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
6. Ground: 50 percent capacity, integral with housing.
7. Ground: 50 percent capacity, internal bus bar of material matching bus material.
8. Ground: 50 percent capacity, isolated, internal bus bar of material matching bus material.
9. Enclosure: [**Steel**] [**Aluminum**], with manufacturer's standard finish.
10. Plug-in Openings: 24 inches (600 mm) o.c. on each side of bus, and hinged covers over unused openings. Plug-in openings shall be finger-safe with covers open or closed.
11. Fittings and Accessories: Manufacturer's standard.
12. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
13. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs and up to 16 feet (5 m) for vertically mounted runs.
14. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

C. Joints:

1. Busway joints shall use one high-strength steel bolt with Belleville washers.
2. Bolts shall be torque indicating type and at ground potential.
3. Bolts shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
4. Access shall be required to only one side of the busway for tightening joint bolts.
5. Joint connection assemblies shall be removable without disturbing adjacent busway lengths.
6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.

2.4 PLUG-IN DEVICES

A. Fusible Switches: NEMA KS 1, heavy duty; with [**R-type rejection**] [**J-type**] [**L-type**] fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position. See Section 262813 "Fuses" for fuses and fuse installation requirements.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Molded-Case Circuit Breakers: UL 489; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. SPD: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate SPD from busway. SPD product and installation requirements are specified in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Motor Controllers: NEMA ICS 2, Class A, full voltage, nonreversing, across the line unless otherwise indicated.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Control Circuit: 120 V; obtained from [**integral control power transformer**] <**Insert source of control power**> with a control power [**transformer**] [**source**] of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
3. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.
    a. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with [**R-type rejection**] [**J-type**] fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1, as certified by an NRTL acceptable to authorities having jurisdiction. See Section 262813 "Fuses" for fuses and fuse installation requirements.
    b. Circuit-Breaker Disconnecting Means: UL 489, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
4. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, [**Class 10**] [**Class 20**] [**Class 30**] tripping characteristic. Overload relays shall have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
5. Adjustable Overload Relay: Dipswitch selected for motor running overload protection with NEMA ICS 2, [**Class 10**] [**Class 20**] [**Class 30**] tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Adjustable

overload relays shall have Class II ground-fault protection with start and run delays to prevent nuisance trip on starting.

E. Multispeed Magnetic Controllers: Match controller to motor type, application, and number of speeds.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Compelling relay ensures motor starts only at low speed.
3. Accelerating relay ensures properly timed acceleration through speeds lower than that selected.
4. Decelerating relay ensures automatically timed deceleration through each speed.

F. Accessories: Hookstick operator, adjustable to maximum extension of [**14 feet (4.3 m)**] <**Insert dimension**>.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including luminaires, HVAC equipment, fire-suppression system, and partition assemblies.

B. Equipment Mounting:

1. Install enclosed bus assemblies on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."
2. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
3. Support bus assembly to prevent twisting from eccentric loading.
4. Support bus assembly with not less than [**3/8-inch (10-mm)**] <**Insert dimension**> steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
5. Fasten supports securely to building structure according to Section 260529 "Hangers and Supports for Electrical Systems."

6. Bolts and nuts that are loosened for any reason after tightening to manufacturer's recommended torque setting shall be discarded and replaced with new bolts and nuts.

D. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

E. Construct rated firestop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Section 078413 "Penetration Firestopping."

F. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.

G. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

H. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

I. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

J. Comply with NECA 1.

## 3.2 CONNECTIONS

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

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

C. Terminate to transformer enclosures with matching bus assemblies according to Section 262200 "Low-Voltage Transformers."

D. Terminate to switchgear enclosures with matching bus assemblies according to Section 262300 "Low-Voltage Switchgear."

E. Terminate to switchboard enclosures with matching bus assemblies according to Section 262413 "Switchboards."

F. Terminate to panelboard enclosures with matching bus assemblies according to Section 262416 "Panelboards."

G. Terminate to motor-control centers enclosures with matching bus assemblies according to Section 262419 "Motor-Control Centers."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

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

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

1. After installing equipment test, for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify correct connection according to single-line diagram.
    e. Inspect bolted electrical connections for high resistance using one or more of the following methods:

        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
        3) Perform thermographic survey.

3. Electrical Tests:

    a. Perform insulation resistance measurements through bolted connections and bus joints with low-resistance ohmmeter.
    b. Perform insulation resistance tests of each busway, phase to phase, and phase to ground.
    c. Perform a dielectric withstand voltage test on each busway, phase to ground with phases not under test grounded for one minute.
    d. Measure resistance of assembled busway sections on insulated busway and compare values with adjacent phases.
    e. Perform phasing test on each busway tie section energized by separate sources.
    f. Verify operation of busway space heaters.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

F. Enclosed bus assemblies will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

## 3.4 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges[ **and overload relay trip settings**] as indicated.

## 3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

## 3.6 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 262500

# SECTION 262726 - WIRING DEVICES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. USB receptacles.
3. GFCI receptacles, 125 V, 20 A.
4. Toggle switches, 120/277 V, 20 A.
5. Wall-box dimmers.
6. Wall plates.
7. Floor service fittings.

### 1.3 DEFINITIONS

A. BAS: Building automation system.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

### 1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with requirements in this Section.

F. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

G. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Uninterruptible Power System ‘UPS’: Red.

H. Wall Plate Color: For plastic covers, match device color.

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:

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

a. Eaton (Arrow Hart) #5351 (single), CR5362 (duplex).
b. Hubbell Incorporated; Wiring Device-Kellems #HBL5351 (single), #HBL5352 (duplex).
c. Leviton Manufacturing Co., Inc #5891 (single), #5352 (duplex).
d. Pass & Seymour/Legrand (Pass & Seymour) #5361 (single), #5362 (duplex).

2. Description: Two pole, three wire, and self-grounding.

3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.

B. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.

3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.3 USB RECEPTACLES

A. USB Charging Receptacles:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.

3. USB Receptacles: Dual, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. Standards: Comply with UL 1310 and USB 3.0 devices.

B. Tamper-Resistant Duplex and USB Charging Receptacles:

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

   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.

3. Line Voltage Receptacles: Two pole, three wire, and self-grounding; NEMA WD 6, Configuration 5-20R.
4. USB Receptacles: Dual USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
5. Standards: Comply with UL 498, UL 1310, USB 3.0 devices, and FS W-C-596.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.4 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A.

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:
   1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Type: [**Feed**] [**Non-feed**] through.
   4. Standards: Comply with UL 498 and UL 943 Class A.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.5 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Standards: Comply with UL 20 and FS W-S-896.

B. Antimicrobial, Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
   2. Standards: Comply with UL 20 and FS W-S-896.

C. Two-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Comply with UL 20 and FS W-S-896.

D. Antimicrobial, Double-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
   2. Standards: Comply with UL 20 and FS W-S-896.

E. Three-Way Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Comply with UL 20 and FS W-S-896.

F. Antimicrobial, Three-Way Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
   2. Standards: Comply with UL 20 and FS W-S-896.

G. Four-Way Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Standards: Comply with UL 20 and FS W-S-896.

H. Pilot-Light, Single-Pole Switches: 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: Illuminated when switch is [**on**] [**off**].
   2. Standards: Comply with UL 20 and FS W-S-896.

I. Lighted Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: Handle illuminated when switch is [**on**] [**off**].
   2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

J. Key-Operated, Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: Factory-supplied key in lieu of switch handle.
   2. Standards: Comply with UL 20 and FS W-S-896.

K. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A <**Insert drawing designation**>:
   1. Description: For use with mechanically held lighting contactors.
   2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

L. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A <**Insert drawing designation**>:

   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   2. Description: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
   3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

## 2.6 DIMMERS

A. Wall-Box Dimmers:

   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   2. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
   3. Control: Continuously adjustable [**slider**] [**toggle switch**] [**rotary knob**]; with single-pole or three-way switching.
   4. Standards: Comply with UL 1472.
   5. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

      a. 600 W; dimmers shall require no derating when ganged with other devices.[ **Illuminated when "off."**]
      b. <**Insert wattage ratings and descriptions**>.
   6. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

## 2.7 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: [**Steel with white baked enamel, suitable for field painting**] [**Smooth, high-impact thermoplastic**] [**0.035-inch-thick, satin-finished,**

**Type 302 stainless steel**] [**0.04-inch-thick, brushed brass with factory polymer finish**] [**0.05-inch-thick, anodized aluminum**] [**0.04-inch-thick steel with chrome-plated finish**].

3. Material for Unfinished Spaces: [**Galvanized steel**] [**Smooth, high-impact thermoplastic**].
4. Material for Damp Locations: [**Thermoplastic**] [**Cast aluminum**] with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant[**, die-cast aluminum**] [**thermoplastic**] with lockable cover.

D. Antimicrobial Cover Plates:

1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Tarnish resistant.

## 2.8 FLOOR SERVICE FITTINGS

A. Flush-Type Floor Service Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.
3. Compartments: Barrier separates power from voice and data communication cabling.
4. Service Plate and Cover: [**Rectangular**] [**Round**], [**die-cast aluminum**] [**solid brass**] with satin finish.
5. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
6. Data Communication Outlet: [**Blank cover with bushed cable opening.**] [**Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."**]

B. Flap-Type Service Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Type: Modular, flap-type, dual-service units suitable for wiring method used, with flaps flush with finished floor.
3. Compartments: Barrier separates power from voice and data communication cabling.
4. Flaps: [**Rectangular**] [**Round**], [**die-cast aluminum**] [**solid brass**] with satin finish.
5. Service Plate: Same finish as flaps.
6. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
7. Data Communication Outlet: [**Blank cover with bushed cable opening.**] [**Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."**]

C. Above-Floor Service Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Type: Modular, above-floor, dual-service units suitable for wiring method used.
3. Compartments: Barrier separates power from voice and data communication cabling.
4. Service Plate: [**Rectangular**] [**Round**], [**die-cast aluminum**] [**solid brass**] with satin finish.
5. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
6. Data Communication Outlet: [**Blank cover with bushed cable opening.**] [**Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."**]

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles [**up**] [**down**], and on horizontally mounted receptacles to the [**right**] [**left**].
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

## 3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with [**black**] [**white**] [**red**]-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

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

1. In healthcare facilities, prepare reports that comply with NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade [**convenience outlets in patient-care areas**] [**hospital-grade outlets**] for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz..

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 262726

# SECTION 262813 - FUSES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Motor-control centers.
c. Panelboards.
d. Switchboards.
e. Enclosed controllers.
f. Enclosed switches.

2. Spare-fuse cabinets.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.

2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bussmann, an Eaton business.
2. Edison; a brand of Bussmann by Eaton.
3. Ferras Shawmut, Inc.
4. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 600-V, zero- to 600-A rating, 200k AIC, time delay.
2. Type CC: 600-V, zero- to 30-A rating, 200k AIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: Class RK1, time delay.
2. Motor Branch Circuits: Class RK1, time delay.
3. Other Branch Circuits: Class RK1, time delay.
4. Control Transformer Circuits: Class CC, time delay, control transformer duty.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Construction Manager.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

# SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Enclosures.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include wiring diagrams for power, signal, and control wiring.

### 1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

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

1. ABB Inc.
2. Eaton.
3. General Electric Company.
4. Siemens Industry, Inc., Energy Management Division.
5. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Compression type, suitable for number, size, and conductor material.

## 2.4 NONFUSIBLE SWITCHES

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

1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Compression type, suitable for number, size, and conductor material.

## 2.5 MOLDED-CASE CIRCUIT BREAKERS

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

1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action.

The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated.

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

O. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.

3. Application Listing: Appropriate for application;
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Electrical Operator: Provide remote control for on, off, and reset operations.
9. Accessory Control Power Voltage: Integrally mounted, self-powered.

## 2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12) a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel) copper-free cast aluminum alloy (NEMA 250 Types 7, 9).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

3.3 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.

g. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
h. Verify correct phase barrier installation.
i. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.
e. Operate the circuit breaker to ensure smooth operation.

f. Inspect operating mechanism, contacts, and chutes in unsealed units.
g. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and

circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

## 3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

END OF SECTION 262816

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# SECTION 262913.03 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Enclosures.
4. Accessories.
5. Identification.

### 1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. NC: Normally closed.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SCPD: Short-circuit protective device.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.

2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:

1. Each installed magnetic controller type.
2. NRTL listing.
3. Factory-installed accessories.
4. Nameplate legends.
5. SCCR of integrated unit.

## 1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for magnetic controllers, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for magnetic controllers and installed components.
b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
c. Manufacturer's written instructions for setting field-adjustable overload relays.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

1.10 FIELD CONDITIONS

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than23 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet for electromagnetic and manual devices.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

D. Seismic Performance: Magnetic controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the controller will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

## 2.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

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

a. Eaton.
b. General Electric Company.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc., Energy Management Division.
e. Square D; by Schneider Electric.

2. Standard: Comply with NEMA ICS 2, general purpose, Class A.

3. Configuration: Nonreversing.
4. Surface mounting.
5. Red (ENERGIZED) LED pilot light.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

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

a. Eaton.
b. General Electric Company.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc., Energy Management Division.
e. Square D; by Schneider Electric.

2. Configuration: Nonreversing.

3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Pilot Light: Red (RUN); Amber (OVERLOAD TRIPPED) LED.

## 2.3 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

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

1. Eaton.
2. General Electric Company.
3. Rockwell Automation, Inc.
4. Siemens Industry, Inc., Energy Management Division.
5. Square D; by Schneider Electric.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. Spare CPT Capacity as Indicated on Drawings: 200 VA.

G. Overload Relays:

1. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

2.4 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.
b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.

B. Reversible N.C. / N.O. auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Breather assemblies, to maintain interior pressure and release condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

E. Spare control wiring terminal blocks, quantity as indicated; wired.

2.6 IDENTIFICATION

A. Controller Nameplates: Laminated acrylic or melamine plastic signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

### 3.2 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

### 3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Inspect contactors:

1) Verify mechanical operation.
2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

f. Motor-Running Protection:

1) Verify overload element rating is correct for its application.
2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

a. Comply with the recommendations of NFPA 70B, "Testing and Test Methods" Chapter, "Infrared Inspection" Article.
b. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.

c. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each motor controller 11 months after date of Substantial Completion.
d. Report of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:

1) Description of equipment to be tested.
2) Discrepancies.
3) Temperature difference between the area of concern and the reference area.
4) Probable cause of temperature difference.
5) Areas inspected. Identify inaccessible and unobservable areas and equipment.
6) Load conditions at time of inspection.
7) Photographs and thermograms of the deficient area.
8) Recommended action.

e. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. The equipment shall detect emitted radiation and convert detected radiation to a visual signal.
f. Act on inspection results and recommended action, and considering the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

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

END OF SECTION 262913.03

# SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

### 1.3 DEFINITIONS

A. BAS: Building Automation System

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. DDC: Direct digital control.

E. EMI: Electromagnetic interference.

F. LED: Light-emitting diode.

G. NC: Normally closed.

H. NO: Normally open.

I. OCPD: Overcurrent protective device.

J. PID: Control action, proportional plus integral plus derivative.

K. RFI: Radio-frequency interference.

L. VFC: Variable-frequency motor controller.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

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

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Seismic Qualification Certificates: For each VFC, accessories, and components, from manufacturer.

1. Certificate of compliance.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
    b. Manufacturer's written instructions for setting field-adjustable overload relays.
    c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
    d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

## 1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ABB.
2. Cerus Industrial, Inc.
3. Danfoss Inc.
4. Eaton.
5. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
6. Rockwell Automation, Inc.
7. Schneider Electric USA, Inc.
8. Siemens Industry, Inc.
9. Toshiba International Corporation.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

B. Application: Variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for

providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

## 2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 4- to 20-mA dc.
b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS system or other control systems:

a. 0- to 10-V dc.
b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

F. BAS Interface: Factory-installed hardware and software shall interface with BAS to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernets and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet or Echelon Lon Works; protocols accessible via the communications ports.

## 2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

2.7 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 4X.
3. Other Wet or Damp Indoor Locations: Type 4.

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Unguarded.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.
4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

H. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

## 2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

## 3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."

D. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in each fusible-switch VFC.

G. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

J. Comply with NECA 1.

## 3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

## 3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

## 3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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

## 3.6 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable pressure switches.

## 3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

## 3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

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# SECTION 263213.14 - DIESEL ENGINE GENERATORS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes packaged engine generators used to supply non-emergency power, with the following features:

1. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor engine generator enclosure.
7. Vibration isolation devices.
8. Finishes.

B. Related Requirements:

1. Section 262313 "Paralleling Low-Voltage Switchgear" for controls and paralleling equipment for large or multiple parallel engine generators.
2. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

### 1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.

4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, supplied enclosure, subbase-mounted fuel tank, stair/access platform and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion. Warranty shall include labor, parts, mileage and travel time.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

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

1. Caterpillar, Inc.; Electric Power Division.
2. Cummins Power Generation.
3. Generac Power Systems, Inc.
4. Kohler Power Systems.
5. MTU Onsite Energy Corporation.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

### 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, subbase fuel tank, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: 1.5.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine

generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 104 deg F.
2. Altitude: Sea level to 1000 feet.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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

C. Power Rating: Industrial.

D. Service Load: <**Insert number**> kVA.

E. Power Factor: 0.8, lagging.

F. Frequency: 60 Hz.

G. Voltage: 480-V ac.

H. Phase: Three-phase, four wire, wye.

I. Induction Method: Turbocharged.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

L. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated excluding power required for the continued and repeated operation of the unit and auxiliaries.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: 10 seconds.

N. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

## 2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid or nickel-cadmium batteries. Unit shall comply with UL 1236 and include the following features:

a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at

battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

## 2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Provide fuel required for a minimum of 48 hours of run time at full load plus fuel for periodic maintenance operations between fuel refills.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

## 2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run time control set for 30 minutes with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

E. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, for each phase connected to a phase selector switch.
    f. AC ammeter, for each phase connected to a phase selector switch.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.
    i. EPS supplying load indicator.

4. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low-water temperature alarm.
    g. High engine temperature pre-alarm.

h. High engine temperature.
i. High engine temperature shutdown device.
j. Overspeed alarm.
k. Overspeed shutdown device.
l. Low fuel main tank.

1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required in "Fuel Tank Capacity" Subparagraph in "Diesel Fuel-Oil System" Article.

m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature prealarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. Battery high-voltage alarm.
t. Low cranking voltage alarm.
u. Battery-charger malfunction alarm.
v. Battery low-voltage alarm.
w. Lamp test.
x. Contacts for local and remote common alarm.
y. Low-starting air pressure alarm.
z. Low-starting hydraulic pressure alarm.
aa. Remote manual stop shutdown device.
bb. Air shutdown damper alarm when used.
cc. Air shutdown damper shutdown device when used.
dd. Generator overcurrent-protective-device not-closed alarm.
ee. Hours of operation.
ff. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

F. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via BACnet protocol.

G. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

H. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until

silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Generator overcurrent-protective-device not-closed alarm.

I. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

J. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

## 2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Disconnect Switch: Molded-case type; 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

D. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

## 2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12-lead alternator.

E. Range: Provide broad range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within [**15**] [**20**] [**30**] percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within [**5**] [**10**] [**15**] percent and stabilize at rated frequency within [**2**] [**5**] seconds.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Sound Attenuation Level: <**Insert level**>.

B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph.

C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Hinged Doors: With padlocking provisions.

E. Space Heater: Thermostatically controlled and sized to prevent condensation.

F. Lighting: Provide weather-resistant LED lighting with 30 fc average maintained.

G. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

H. Muffler Location: Within enclosure.

I. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

J. Interior Lights with Switch: Factory-wired, vaporproof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

K. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

L. Pre-wired AC distribution panel: 240/120V, 1-phase, 3-wire, 60A/2P main circuit breaker, connected to 120VAC line-neutral and 240VAC line-line, spare breaker provisions and capacity for future upgrades. Components pre-wired by the manufacturer shall include:

1. Battery Charger.
2. Battery Box Heater.
3. Engine Block Heater(s).
4. Control Panel Heater.
5. Convenience Outlet.
6. Space Heater.
7. Lighting.
8. Generator Anti-Condensate Heater.

M. Outdoor stair/access platform.

1. Provide stair and access platform. Platform shall be located to provide access to Generator Control Panel and shall be corrosive resistant (i.e. aluminum or coated steel) and slip resistant. Submit detailed installation and anchoring requirements.

## 2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene or Natural rubber separated by steel shims.
2. Shore A Scale Durometer Rating: [**30**] [**40**] [**45**] [**50**] [**60**] [**65**] [**70**] <**Insert number**>.
3. Number of Layers: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.
4. Minimum Deflection: [**1 inch**] <**Insert value**>.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: [**1 inch**] <**Insert value**>.

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer. Color submitted shall be approved by Owner/Engineer/Architect.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

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

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with [**elastomeric isolator pads**] [**restrained spring isolators**] having a minimum deflection of [**1 inch**] on 4-inch-high concrete base. Secure enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Install and anchor stair/platform on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundations specified in Section 033000 “Cast-in-Place Concrete.”

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."

F. Drain Piping: Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."

G. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."

2. Copper and galvanized steel shall not be used in the fuel-oil piping system.

H. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

## 3.3 CONNECTIONS

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

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Connect fuel piping to engines with a gate valve and union and flexible connector.

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

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one (1) 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

G. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

## 3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

## 3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp Test duration shall be 10 minutes. Calculate polarization index.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Verify correct functioning of the governor and regulator.

2. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
5. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
6. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

D. Coordinate tests with tests for transfer switches and run them concurrently.

E. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

F. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

I. Remove and replace malfunctioning units and retest as specified above.

J. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

L. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

## 3.6 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

## 3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.14

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# SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:

a. Surge suppression.
b. Rectifier-charger.
c. Inverter.
d. Controls and indications.
e. Static bypass transfer switch.
f. [**Internal**] [**External**] maintenance bypass/isolation switch.
g. Output distribution section.
h. Output isolation transformers.
i. Remote status and alarm panels.
j. Remote monitoring provisions.
k. Battery and battery disconnect device.
l. Battery monitoring.
m. <**Insert required major features**>.

### 1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GTO: Gate turn-off thyristor.

C. IGBT: Isolated gate bipolar transistor.

D. LCD: Liquid-crystal display.

E. LED: Light-emitting diode.

F. NiCd: Nickel cadmium.

G. PC: Personal computer.

H. SPD: Surge protection device.

I. THD: Total harmonic distortion.

J. UPS: Uninterruptible power supply.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of UPS.

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

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and [**mounting**] [**attachment**] details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**power quality specialist**] [**testing agency**].

B. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each product, from manufacturer.

D. Factory Test Reports: Comply with specified requirements.

E. Product Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

F. Field quality-control reports.

G. Sample Warranties: For manufacturer's special warranties.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: [**One**] <**Insert number**> for every [**10**] <**Insert number**> of each type and rating, but no fewer than [**one**] [**one set**] <**Insert number**> of each.
2. Cabinet Ventilation Filters: [**One**] <**Insert number**> complete set(s).

1.8 QUALITY ASSURANCE

A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

B. Testing Agency Qualifications: Certified by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F:
2. Warranted Cycle Life for Premium Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F:
3. Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F:

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: [**Two**] [**Three**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Double Conversion, Standard Efficiency:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
c. Power Failure: If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.

2. Double Conversion, Line Interactive:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, with the rectifier-charger and inverter turned off and the battery disconnected.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the rectifier-charger and inverter turn on and the battery supplies energy to provide constant, regulated inverter power output to the load with minimum of 98 percent UPS system efficiency.
c. Power Failure: If normal power fails, there is a maximum 4-microsecond delay while the rectifier-charger and inverter turn on and the battery supplies energy to re-establish constant, regulated power output to the load.

3. Double Conversion, IGBT:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.

c. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.

4. When power is restored at the normal supply terminals of the system, controls shall automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger shall supply power to the load through the inverter and simultaneously recharge the battery.
5. If the battery becomes discharged and normal supply is available, the rectifier-charger shall charge the battery. The rectifier-charger shall automatically shift to float-charge mode on reaching full charge.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch shall switch the load to the normal ac supply circuit without disturbance or interruption.
7. The output power converters shall produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter shall sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
8. The inverter shall be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
9. Should overloads persist past the time limitations, the automatic static transfer switch shall switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch shall return the load to the UPS system.
10. If the battery is disconnected, the UPS shall supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance:

1. Ambient Temperature for Electronic Components: 32 to 104 deg F.
2. Ambient Temperature for Battery: 41 to 95 deg F.
3. Relative Humidity: Zero to 95 percent, noncondensing.
4. Altitude: Sea level to 4000 feet.

## 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. UL Compliance: Listed and labeled by an NRTL to comply with UL 1778.

C. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus [**10**] [**15**] percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is [**30**] [**50**] [**100**] percent unbalanced continuously.

D. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is [**five**] [**10**] [**15**] <**Insert duration**> minutes.

E. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10 percent and minus [**15**] [**20**] [**30**] percent from nominal voltage.

F. Overall UPS Efficiency: Equal to or greater than [**94**] [**95**] <**Insert number**> percent at 100 percent load, [**94**] [**95**] <**Insert number**> percent at 75 percent load, and [**93**] [**94**] <**Insert number**> percent at 25 percent load.

G. Maximum Acoustical Noise: <**Insert value**>, "A" weighting, emanating from any UPS component under any condition of normal operation, measured <**Insert distance**> from nearest surface of component enclosure.

H. Maximum Energizing Inrush Current: [**Six times the full-load current**] [**Eight times the full-load current**] [**Soft start linear input current rise to 100 percent over a 1- to 40-second period, factory set at 10 seconds**].

I. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.

J. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.

K. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.

L. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description: Rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
2. Description: THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.

M. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

N. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

O. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.

P. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:

1. 50 Percent: Plus or minus 3 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

Q. Input Power Factor: A minimum of [**0.90**] [**0.95**] lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.

R. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging shall not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:

1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.

S. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

## 2.3 UPS SYSTEMS

A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

D. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

E. Configuration: [**Single-cabinet**] [**Multicabinet**] [**Field-assembled, multicabinet**] modular style units.

F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

G. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

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

I. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future [**25**] <**Insert number**> percent increase in UPS capacity.

J. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

K. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

L. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

## 2.4 SURGE SUPPRESSION

A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch[**, and maintenance bypass/isolation switch**]. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, [**Category B**] [**Category C**].
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

## 2.5 RECTIFIER-CHARGER

A. Description: Voltage source converter, [**six**] [**12**]-pulse [**IGBT**] [**GTO**] rectifier.

B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger shall be matched to the battery type supplied.

F. NiCd Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging shall be terminated when the rate of temperature rise reaches 1.8 deg F per minute. If the battery reaches 140 deg F prior to reaching this rate of temperature rise, charging shall terminate. Chargers that determine full charge by voltage measurement to sense a 10-mV drop per cell when reaching full charge are also acceptable.

2.6 INVERTER

A. Description: Pulse-width modulated, [**carrier stored trench IGBT**] [**IGBT**] with sinusoidal output.

B. Description: Pulse-width modulated, [**carrier stored trench IGBT**] [**IGBT**] with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.7 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: [**Labeled LED**] [**Plain-language messages on a digital LCD**].

1. Quantitative indications shall include the following:

a. Input voltage, each phase, line to line.
b. Input current, each phase, line to line.
c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.
e. System output voltage, each phase, line to line.
f. System output current, each phase.
g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:

a. Normal operation.
b. Load-on bypass.
c. Load-on battery.
d. Inverter off.
e. Alarm condition.

3. Alarm indications shall include the following:

a. Bypass ac input overvoltage or undervoltage.
b. Bypass ac input overfrequency or underfrequency.
c. Bypass ac input and inverter out of synchronization.
d. Bypass ac input wrong-phase rotation.
e. Bypass ac input single-phase condition.

f. Bypass ac input filter fuse blown.
g. Internal frequency standard in use.
h. Battery system alarm.
i. Control power failure.
j. Fan failure.
k. UPS overload.
l. Battery-charging control faulty.
m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.
w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.
aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.8 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.

C. Input SPD: [**80**] [**160**] kA.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.
3. Switch shall electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but shall allow primary power to the UPS for testing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full-load UPS current.

D. Mounting Provisions: [**Internal to system cabinet**] [**Separate wall- or floor-mounted unit**].

E. Key interlock with key that is released only when the rectifier-charger and inverter are bypassed by the static bypass transfer switch. Key shall be required to unlock maintenance bypass/isolation switch before switching from open (normal) position to closed position. Lock shall be designed specifically for mechanical and electrical component interlocking.

2.10 OUTPUT DISTRIBUTION SECTION

A. Panelboards: Comply with Section 262416 "Panelboards," except provide assembly integral to UPS cabinet.

2.11 OUTPUT ISOLATION TRANSFORMER

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: [**Shielded unit**] [**Unit**] with low forward transfer impedance up to 3 kHz, minimum. Include the following features:

1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately [**4**] [**9**] [**13**] [**20**].
2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.

3. Regulation: 5 percent, maximum, at rated nonlinear load current.
4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
5. Electrostatic Shielding of Windings: Independent for each winding.
6. Coil Leads: Physically arranged for minimum interlead capacitance.
7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
8. Capacitive Coupling between Primary and Secondary: 33 pF, maximum, over a frequency range of 20 Hz to 1 MHz.

## 2.12 REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicating [**five**] <**Insert quantity**> basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

## 2.13 REMOTE MONITORING

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units for data transmission via RS-485, Ethernet, or web-based link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."

## 2.14 BATTERY

A. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

B. Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers. Mount on [**two-tier,**] [**three-tier,**] acid-resistant, painted steel racks. Assembly

includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.

C. Description: Flooded cell, heavy-duty, industrial, NiCd units in polypropylene containers. Mount on [**two-tier,**] [**three-tier,**] acid-resistant, painted steel racks, complete with battery disconnect switch and intercell connectors.

D. Description: Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, NiCd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.

1. Factory assembled in an isolated compartment of UPS cabinet.
2. Mount on [**two-tier,**] [**three-tier,**] acid-resistant, painted steel racks.
3. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

E. <Double click here to find, evaluate, and insert list of manufacturers and products.>

F. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

G. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units, complete with battery disconnect switch and intercell connectors.

1. Factory assembled in an isolated compartment of UPS cabinet.
2. Mount on [**two-tier,**] [**three-tier,**] acid-resistant, painted steel racks.
3. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

H. Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers. Mount on [**two-tier,**] [**three-tier,**] acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.

I. Description: Flooded cell, heavy-duty, industrial, NiCd units in polypropylene containers. Mount on [**two-tier,**] [**three-tier,**] acid-resistant, painted steel racks, complete with battery disconnect switch and intercell connectors.

J. Description: Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, NiCd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.

1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

K. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

## 2.15 BASIC BATTERY MONITORING

A. Description: Continuous, real-time capture of battery performance data.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

D. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater than 167 deg F occurs within the compartment.

E. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 167 deg F occurs within the compartment.

F. Annunciation of Alarms: At UPS control panel and remotely.

## 2.16 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
2. Connections for data transmission via RS-485 link, [**and**] [**network interface and**] external signal wiring to [**computer**] [**electrical power monitoring and control equipment**]. External signal wiring and computer are not specified in this Section.
3. USB ports for printer and accessories.
4. PC-based software designed to store and analyze battery data, compile reports on individual-cell parameters and total battery performance trends, and provide data for scheduling and prioritizing battery maintenance.

B. Performance: Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events, record measurements timed to nearest second; including measurements of the following parameters:

1. Total battery voltage and ambient temperature.
2. Individual-cell voltage, impedance, and temperature, and string current. During battery-discharging events such as utility outages, measures battery and cell voltages, battery string current and records values versus time to nearest second.
3. Individual-cell electrolyte levels.

## 2.17 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measure and record each discharge event, classify it according to duration category and total discharges according to warranty criteria, and display remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminal. Initiate an alarm for excursions outside the proper float-voltage level.
2. Monitoring: Ambient temperature at battery; initiate an alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provide access to monitored data using front panel display.
4. Alarm Contacts: Arrange to initiate [**local**] [**remote**] alarm for [**battery discharge events**] [**abnormal temperature**] [**abnormal battery voltage or temperature**].
5. Memory: Store recorded data in nonvolatile electronic memory.
6. Ethernet Port: Permits downloading of data to a PC.

## 2.18 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use [**actual batteries that are part of final installation**] [**the same type of batteries that are part of final installation**] [**simulated battery testing**]. Include the following:

1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

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

C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection according to Section 262813 "Fuses" if required for coordination with UPS overcurrent protective device requirements.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[ **and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base 6 inches from the outer edge of the base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

G. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

## 3.3 GROUNDING

A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Separately Derived Systems: If part of a listed power supply for a data-processing room, comply with manufacturer's written instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

## 3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify each battery cell individually.

## 3.5 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform tests and inspections[ **with the assistance of a factory-authorized service representative**].

E. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:

    a. Inspect anchorage, alignment, grounding, and required clearances.
    b. Component type and labeling verification.
    c. Ratings of installed components.

2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:

    a. Use of low-resistance ohmmeter according to Section 7.22.2.2 of NETA ATS.
    b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or Table 100.12 of NETA ATS.
    c. Perform thermographic survey according to Section 9 of NETA ATS.

4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.

    a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 of NETA ATS.
    b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.
    c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup, Use secondary current injection to test trip functions.
    d. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data.
    e. Verify operation of charging mechanism.
    f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.

8. Test automatic transfer switches.

    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, according to Section 7.22.3.1 of NETA ATS.
    b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or

for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.

c. Perform a contact/pole-resistance test.
d. Verify settings and operation of control devices.
e. Calibrate and set all relays and timers according to Section 7.9 of NETA ATS.
f. Verify phase rotation, phasing, and synchronized operation as required by the application.
g. Perform automatic transfer tests.

1) Simulate loss of normal power.
2) Return to normal power.
3) Simulate loss of emergency power.
4) Simulate all forms of single-phase conditions.

h. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Time delay on transfer.
3) Alternative source voltage-sensing and frequency-sensing relays.
4) Automatic transfer operation.
5) Interlocks and limit switch function.
6) Time delay and retransfer on normal power restoration.

9. Test direct current system's batteries.

a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
b. [**Verify electrolyte level. Measure electrolyte level, specific gravity, and temperature.**]
c. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
d. Verify all charger functions and alarms.
e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
f. Perform a load test according to manufacturer's published data or IEEE 450.
g. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
h. Test values.

1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Charger float and equalize voltage levels shall be according to battery manufacturer's published data.
3) The results of charger functions and alarms shall be according to manufacturer's published data.
4) Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.

5) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
6) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
7) Results of load tests shall be according to manufacturer's published data or IEEE 450.

10. Test communication of status and alarms to remote monitoring equipment.
11. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous [**six months**] <**Insert time**> according to NIST standards.

a. Simulate malfunctions to verify protective device operation.
b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
d. Test output voltage under specified transient-load conditions.
e. Test efficiency at 50, 75, and 100 percent of rated loads.
f. Test remote status and alarm panel functions.
g. Test battery-monitoring system functions.

F. Seismic-restraint tests and inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
2. Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

G. The UPS system will be considered defective if it does not pass tests and inspections.

H. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

I. Prepare test and inspection reports.

## 3.7 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated[ **for each UPS system**].

B. Monitoring and Testing Schedule: Perform monitoring and testing in [**a single 10-day period**] [**four 10-day periods, each in a different season of the year**] <**Insert period**>.

1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.
10. Battery cell temperature during charging.
11. Ambient temperature.

D. Monitoring and Testing Procedures[ **for Each Test Period**]:

1. Exploratory Period: For the first [**two**] <**Insert number**> days[ **of the first scheduled monitoring and testing period**], make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

    a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
    c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.

d. Using loads and devices available as part of the facility's installed systems and equipment[ **and a temporarily connected portable generator set**], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
e. Using temporarily connected resistive/inductive load banks[ **and a temporarily connected portable generator set**], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing; repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in [**each** ]report:

1. Descriptions of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendations for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

## 3.8 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

# SECTION 263600 - TRANSFER SWITCHES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less, including the following:

1. Bypass/isolation switches.
2. Remote annunciator system.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

### 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 WARRANTY

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

1. Warranty Period: 5 years from date of Substantial Completion. Warranty shall include labor, parts, mileage and travel time.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. Comply with NEMA ICS 1.

C. Comply with NFPA 110.

D. Comply with UL 1008 unless requirements of these Specifications are stricter.

E. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

F. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for [**three**] [**30**] <**Insert number**> cycles.

G. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

J. Service-Rated Transfer Switch:

1. Comply with UL 869A and UL 489.
2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
3. In systems with a neutral, the bonding connection shall be on the neutral bus.
4. Provide removable link for temporary separation of the service and load grounded conductors.
5. Surge Protective Device: Service rated.
6. Ground-Fault Protection: Comply with UL 1008 for [**normal bus**] [**normal and alternative buses**].
7. Service Disconnecting Means: Externally operated, manual [**mechanically**] [**electrically**] actuated.

K. Neutral Switching: Where four-pole switches are indicated, provide [**neutral pole switched simultaneously with phase poles**] [**overlapping neutral contacts**].

L. Neutral Terminal: Solid and fully rated unless otherwise indicated.

M. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

N. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

O. Battery Charger: For generator starting batteries.

1. Float type, rated [**2**] [**10**] A.
2. Ammeter to display charging current.

3. Fused ac inputs and dc outputs.

P. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

Q. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable [**with printed**] [**tape**] [**shrinkable sleeve**] markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via [**rear**] [**front**] access.

R. Enclosures: General-purpose NEMA 250, [**Type 1**] [**Type 3R**] [**Type 4X**] [**Type 12**], complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

## 2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: [**Tin-plated aluminum**] [**Hard-drawn copper, 98 percent conductivity**].
6. Main and Neutral Lugs: [**Compression**] [**Mechanical**] type.
7. Ground Lugs and Bus-Configured Terminators: [**Compression**] [**Mechanical**] type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.
10. <**Insert features**>.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

F. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
    c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

G. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

H. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

I. Electric [**Nonautomatic** ]Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

J. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

K. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

L. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal [**and Alternate** ]Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
b. Push-button programming control with digital display of settings.
c. Integral battery operation of time switch when normal control power is unavailable.

M. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

## 2.3 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using contactor-based components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: [**Tin-plated aluminum**] [**Hard-drawn copper, 98 percent conductivity**].
6. Main and Neutral Lugs: [**Compression**] [**Mechanical**] type.
7. Ground Lugs and Bus-Configured Terminators: [**Compression**] [**Mechanical**] type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

10. <**Insert features**>.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

F. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
    c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

G. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

H. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

I. Electric [**Nonautomatic** ]Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

J. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

K. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

L. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.

M. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal [**and Alternative** ]Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.

12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

N. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

## 2.4 TRANSFER SWITCH ACESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources.

Include the following features for each combined automatic transfer switch and bypass/isolation switch:

a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
d. Transition: Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
h. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
i. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:

a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
b. Switch position.
c. Switch in test mode.
d. Failure of communication link.

4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

a. Indicating Lights: Grouped for each transfer switch monitored.

b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
d. Lamp Test: Push-to-test or lamp-test switch on front panel.

## 2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency and legally required systems. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
4. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

## 3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

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

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

D. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."

E. Route and brace conductors according to manufacturer's written instructions. and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

F. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

G. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

## 3.3 FIELD QUALITY CONTROL

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

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

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.

b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify that the unit is clean.
e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Verify that manual transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.
k. Perform visual and mechanical inspection of surge arresters.
l. Inspect control power transformers.

    1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
    3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

    a. Perform insulation-resistance tests on all control wiring with respect to ground.
    b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
    c. Verify settings and operation of control devices.
    d. Calibrate and set all relays and timers.
    e. Verify phase rotation, phasing, and synchronized operation.
    f. Perform automatic transfer tests.
    g. Verify correct operation and timing of the following functions:

        1) Normal source voltage-sensing and frequency-sensing relays.
        2) Engine start sequence.
        3) Time delay on transfer.
        4) Alternative source voltage-sensing and frequency-sensing relays.
        5) Automatic transfer operation.
        6) Interlocks and limit switch function.
        7) Time delay and retransfer on normal power restoration.
        8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages

and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Transfer switches will be considered defective if they do not pass tests and inspections.

F. Remove and replace malfunctioning units and retest as specified above.

G. Prepare test and inspection reports.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

## 3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600

# SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1. Main Switchboard ‘MDP’ – 480/277V, 3-phase, 4-wire.
2. Emergency Distribution Switchboard ‘DP-O’ - 480/277V, 3-phase, 4-wire.
3. Emergency Distribution Panel ‘DP-L’ - 480/277V, 3-phase, 4-wire.
4. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
5. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
6. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
7. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
8. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
9. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
10. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
11. Lighting Panel ‘xxx’ - 480/277V, 3-phase, 4-wire.
12. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
13. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
14. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
15. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
16. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
17. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
18. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
19. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
20. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
21. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.
22. Lighting Panel ‘xxx’ - 208/120V, 3-phase, 4-wire.

### 1.3 REFERENCED STANDARDS

A. IEEE C62.41: IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits (ANSI).

B. IEEE C62.45: IEEE Guide for Surge Suppressor Testing (ANSI).

C. NETA ATS: Acceptance Testing Specifications; Section 7.19, "Low-Voltage Surge Protection Devices".

D. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum).

E. NEMA WD 6: Wiring Device--Dimensional Requirements.

F. NFPA 70: National Electrical Code.

G. UL 486A: Wire Connectors and Soldering Lugs for Use with Copper Conductors.

H. UL 1283: Electromagnetic Interference Filters.

I. UL 1449 (3rd Edition Effective 9/29/2009): UL1149 4th Edition Effective 3/26/2016 Surge Protection Devices.

1.4 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. SCCR: Short-circuit current rating.

E. SPD: Surge protective device.

F. VPR: Voltage protection rating.

1.5 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
3. Shipping, installed, and operating weights; furnished specialties; and accessories.

B. Product Certificates: Signed by manufacturers of surge protection devices, certifying that products furnished comply with the following testing and labeling requirements:

1. UL 1283 certification by an OSHA approved NRTL.
2. UL 1449 (3rd Edition Effective 9/29/2009) 4th Edition Effective 3/26/2016 listing and classification by an OSHA approved NRTL.
3. NEMA LS-1 Single Pulse

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

D. Maintenance Data: For surge protection devices to include in maintenance manuals specified in Division 1.

E. Warranties: Special warranties specified in this Section.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.8 WARRANTY

A. General Warranty: Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Fifteen (15) years from date of Substantial Completion for TG and CGP series.

1.9 SERVICE CONDITIONS

A. Rate surge protective devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: minus 20 degrees F to plus 120 degrees F.
3. Humidity: 0 to 85 percent, non-condensing.
4. Altitude: Less than 20,000 feet above sea level.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

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

1. Current Technology Inc.

2. Substitutions need to be submitted to Engineer for review a minimum of 10-days prior to bid date with a list of any deviations or exceptions from this specification.

B. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. Comply with UL 1449. 4th Edition Effective 3/26/2016.

E. MCOV of the SPD shall be the nominal system voltage.

2.2 PANEL SUPPRESSORS

A. Comply with UL 1449 (4th Edition) Type 1, tested at Inominal Rating: 20 kA.

B. Per ANSI/IEEE C62.41.1-2002, C62.41.2-2002 and C62.45-2002, the SPD system shall be repetitive surge current capacity tested in every mode using a 1.2 x 50 μsec, 20KV open circuit voltage, 8 x 20 μsec, 200KA short circuit current ANSI/IEEE C62.41 Category C3 waveform at one minute interval. Minimum repetitive strikes with less than 10% degradation of clamping voltage shall be 3500 repetitive C3 strikes.

C. Single Pulse Surge Testing: The maximum single-pulse surge current capacity per mode shall be verified through testing at an independent third party testing facility. Testing shall be conducted in each mode of the device and all tested modes shall be from the same test sample. This test shall include all components of the SPD system, including disconnects (if applicable) and fusing as a completed assembly. Individual component testing, module testing only, or subsystem testing of the SPD for compliance with this section will not be acceptable. Ratings based on the arithmetic sum of the ratings of the individual MOVs in a given mode are not acceptable. Testing that causes damage to the device, fuse operation, or voltage clamping performance degradation by more than 10% is not acceptable. The Single Pulse Surge Current Capacity shall be as below:

1. 150kA per mode (Main Switchboard).
2. 80kA per mode (Emergency Distribution Switchboards and Panels).
3. 60kA per mode (Lighting Panels)

D. Filtering: The SPD shall provide a noise filtering system capable of attenuating noise levels produced by electromagnetic interference and radio frequency interference (EMI/RFI). The

system's filtering characteristics shall be expressed in decibels (dB) of attenuation at no less than 8 points over a frequency spectrum between 50kHz and 100MHz. The noise filtering system shall also be listed to UL 1283 by an approved NRTC, as an electromagnetic interference filter.

E. Fusing: Each MOV shall be individually fused and designed to operate only in the event of an MOV failure within the SPD. In the event of an MOV failure, the fuse will operate to remove the failed MOV from the circuit. The remaining MOV's and fuses will stay intact to handle subsequent surges. The fusing included with the SPD system shall be required to meet the above requirement and shall be included with the above testing guidelines. Overcurrent fusing that limits the rated single pulse surge current of the SPD is not acceptable. Replaceable cartridge type per phase or per mode overcurrent fusing is not acceptable where there is more than one MOV per mode.

F. Fault Current Capability: The unit shall be capable of interrupting up to a 200kA symmetrical fault current with 600VAC applied without the need of an upstream overcurrent protection device (fuse or circuit breaker).

G. UL 1449 Voltage Protection Rating: The unit shall be UL 1449 3rd Edition 4th Edition Effective 3/26/2016Listed by a Nationally Recognized Testing Laboratory and shall be as follows for L-N, L-G, N-G, and L-L, modes: Note: the below values are for a 120/240 or 120/208 volt systems, for 277/480 volts the VPR's are 1200V L-N, 1200V L-G, 1000V N-G, 2000V L-L

1. Main Distribution Panel: 150kA rated products (Current Technology TG3-150-208-3Y-PNB-M3-F-2):

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.
    d. Line to Line: 1200 V.

2. Emergency Distribution Panel: 80kA rated products (Current Technology CGP-080-120/208-3GY):

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.
    d. Line to Line: 1200 V.

3. Lighting Panels: 60kA rated products (Current Technology CGP-060-120/208-3GY):

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.
    d. Line to Line: 1200 V.

SPD units shall provide protection status indication via a tri-colored LED per phase. The tri-colored LED shall report when the SPD has reached 75% of remaining useful life, and 40% of remaining useful life.

H. Monitoring Contacts: The unit shall come standard with Form C dry relay contacts (N.O. and N.C.) for remote monitoring capability, and internal audible alarm with silence button.

I. Event Counter (Main Distribution Panel only): The unit shall come standard with a transient event counter with LCD panel display and reset button on the front cover.

J. Enclosure: The unit shall be supplied in a NEMA type 1 enclosure rated for indoor applications.

## PART 3 - EXECUTION

### 3.1 COORDINATION

A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.

### 3.2 INSTALLATION

A. Placing into Service: Do not energize or connect service entrance equipment, or power or lighting panelboards to their sources until the surge protective devices are installed and connected. Verify system voltage prior to energizing surge protective device. When the cable connection length, between the SPD and the switchboard or panelboard, exceeds more than 6 lineal feet, the Contractor shall furnish and install a low impedance connection system from Current Technology, Model HPI, to maximize the performance of the SPD in mitigating the effects of transient voltage surges to the client’s protected systems

B. Comply with NECA 1.

C. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

D. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible; adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer and Engineer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

E. Use crimped connectors and splices only. Wire nuts are unacceptable.

F. Wiring:

1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## 3.3 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

## 3.4 FIELD QUALITY CONTROL AND START-UP

A. Perform the following the following field quality-control tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
4. After installing surge protective devices, but before electrical circuitry has been energized, test for compliance with requirements.
5. Complete startup checks according to manufacturer's written instructions.
6. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.
7. Energize SPDs after power system has been energized, stabilized, and tested.

B. Manufacturer's Field Service: Upon completion of installation and prior to energization, a factory-authorized local service representative shall provide product start-up testing services. The tests shall include:

1. On-Line Testing: Verification that all suppression and filtering paths are operating with 100% protection as well as verification of proper facility neutral-to-ground bond by measuring neutral-to-ground current and voltage.
2. Off-line testing: Impulse injection to verify the system tolerances as well as verification of proper facility neutral-to-ground bond. To be compared to factory benchmark test parameters supplied with each individual unit.

C. The SPD manufacturer’s technician shall perform a system checkout and start-up in the field to assure proper installation, operation and to initiate the warranty of the system. The technician will be required to do the following:

1. Verify voltage clamping levels utilizing a diagnostic test kit, comparing factory readings to installed readings.
2. Verify N-G connection.
3. Record information to a product signature card for each product installed

D. Documentation and Reporting:

1. Prepare test and inspection reports.

a. A copy of the start-up test results and the factory benchmark testing results shall be provided to the Engineer and the Owner for confirmation of proper system function.
b. This letter shall also confirm that all neutral-to-ground bonds were verified through testing and visual inspection, and that all grounding bonds were observed to be in place.
c. Include Operation and Maintenance Manual.

E. An SPD will be considered defective if it does not pass tests and inspections. Repair or replace malfunctioning units. Retest after repairs or replacements are made.

## 3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain surge protective devices.

1. Train Owner's maintenance personnel on procedures and schedules for maintaining suppressors.
2. Review data to be included in operation and maintenance manuals. Refer to Division 017823 “Operation and Maintenance Data.”
3. Schedule training with Owner, through Construction Manager, with a seven (7) day advanced notice.

END OF SECTION 264313

# SECTION 265119 - LED INTERIOR LIGHTING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes the following types of LED luminaires:

1. Cylinder.
2. Downlight.
3. Highbay, linear.
4. Highbay, nonlinear.
5. Linear industrial.
6. Recessed, linear.
7. Strip light.
8. Surface mount, linear.
9. Surface mount, nonlinear.
10. Suspended, linear.
11. Suspended, nonlinear.

B. Related Requirements:

1. Section 262726 “Wiring Devices” for manual lighting control switches and dimmer switches.

2. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

### 1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

## 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

## 1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of luminaire.

C. Sample warranty.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

B. Ambient Temperature: 5 to 104 deg F.

C. Altitude: Sea level to 1000 feet.

2.2 LUMINAIRE REQUIREMENTS

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

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI.

C. Standards:

1. ENERGY STAR certified.
2. UL Listing: Listed for damp location.
3. Recessed luminaires shall comply with NEMA LE 4.

D. CRI of minimum 80. CCT of 4100 K.

E. Nominal Operating Voltage: 277 V ac.

F. Rated lamp life of 50,000 hours to L70.

G. Internal driver.

H. Dimmable from 100 percent to 0 percent of maximum light output. Dimmable drivers shall be compatible with dimmable switches.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. Attached using through bolts and backing plates on either side of wall.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:

a. Two 5/32-inch- diameter aircraft cable supports.
b. Four-point pendant mount with 5/32-inch- diameter aircraft cable supports.
c. Hook mount.

2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

## 3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

## 3.5 FIELD QUALITY CONTROL

A. For inmate occupied areas, provide security sealant between luminaires and ceilings/walls; seal all crevices to avoid concealment of small contraband (i.e. razor blades, etc.). Refer to specification 079200 “Joint Sealants” for security sealant requirements.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

C. Luminaire will be considered defective if it does not pass operation tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 265119

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# SECTION 265613 - LIGHTING POLES AND STANDARDS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Poles and accessories for support of luminaires.
2. Luminaire-lowering devices.

### 1.3 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete luminaire.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

### 1.4 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for regional materials.>
2. <Double click to insert sustainable design text for certified wood.>
3. <Double click to insert sustainable design text for certified wood.>

C. Shop Drawings:

1. Include plans, elevations, sections, and [**mounting**] [**and**] [**attachment**] details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of [**poles**] [**and**] [**pole accessories**].
4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
6. Method and procedure of pole installation. Include manufacturer's written installations.

D. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Qualification Data: For [**Installer**] [**and**] [**testing agency**].

C. Seismic Qualification Data: For <**Insert equipment,**> accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Material Test Reports:

1. For each foundation component, by a qualified testing agency.
2. For each pole, by a qualified testing agency.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: Manufacturer's standard warranty.

H. Soil test reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [**poles**] [**and**] [**luminaire-lowering devices**] to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B660.

B. Store poles on decay-resistant skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of [**pole(s)**] [**and luminaire-lowering device(s)**] that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: [**Five**] <**Insert number**> years from date of Substantial Completion.
2. Warranty Period for Corrosion Resistance: [**Five**] <**Insert number**> years from date of Substantial Completion.
3. Warranty Period for Color Retention: [**Five**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified[ **and the system will be fully operational after the seismic event**]."
2. Component Importance Factor: [**1.5**] [**1.0**].
3. <**Insert requirements for Component Amplification Factor and Component Response Modification Factor**>.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is [**100 mph (45 m/s)**] [**90 mph (40 m/s)**] <**Insert value from AASHTO LTS-6-M for this Project**>.

a. Wind Importance Factor: [**1.0**] <**Insert value from AASHTO LTS-6-M**>.
b. Minimum Design Life: [**50 years**] <**Insert value from AASHTO LTS-6-M**>.
c. Velocity Conversion Factor: [**1.0**] <**Insert value from AASHTO LTS-6-M**>.

2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is [**100 mph (45 m/s)**] [**90 mph (40 m/s)**] <**Insert value from AASHTO LTS-6-M for this Project**>.

a. Wind Importance Factor: [**1.0**] <**Insert value from AASHTO LTS-6-M**>.
b. Minimum Design Life: [**25 years**] <**Insert value from AASHTO LTS-6-M**>.
c. Velocity Conversion Factor: [**1.0**] <**Insert value from AASHTO LTS-6-M**>.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of [**1.1**] <**Insert number**> to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain poles from single manufacturer or producer.

C. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

D. Poles: Comply with ASTM A500/A500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: [**Round, tapered**] [**Round, straight**] [**Square, tapered**] [**Square, straight**].
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

E. Poles: Comply with [**ASTM A240/A240M**] [**ASTM A666**], stainless steel with a minimum yield of 55,000 psig (379 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: [**Round, tapered**] [**Round, straight**] [**Square, tapered**] [**Square, straight**].
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

F. Steel Mast Arms: [**Single-arm**] [**Truss**] [**Davit**] type, continuously welded to pole attachment plate. Material and finish same as plate.

G. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with [**stainless**] [**galvanized**]-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

H. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

I. Fasteners: [**Stainless steel**] [**Galvanized steel**] <**Insert finish or grade**>, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

J. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

K. Steps: Fixed steel, with nonslip treads.

1. For climbing positions, install at 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole, oriented 180 degrees from each other; first step shall be at an elevation 10 feet (3 m) above finished grade.
2. For working positions, install steps on opposite side of pole, oriented 180 degrees from each other at the same elevation.

L. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

M. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch (76-by-130-mm) handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

N. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

O. Platform for Lamp and Ballast Servicing: Factory fabricated of steel, with finish matching that of pole.

P. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

Q. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A123/A123M.

R. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high gloss, high-build polyurethane enamel.

a. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

S. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder Coat: Comply with AAMA 2604.

a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils (64- to 89-um) dry film thickness. Coat interior and exterior of pole for equal corrosion protection.
b. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

## 2.3 ALUMINUM POLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Poles: [**Seamed**] [**Seamless**], extruded structural tube complying with ASTM B221, Alloy 6063-T6, with access handhole in pole wall.

C. Poles: [**Seamed**] [**Seamless**], extruded structural tube complying with ASTM B221, Alloy 6061-T6, with access handhole in in pole wall.

1. Shape: [**Round, tapered**] [**Round, straight**] [**Square, tapered**] [**Square, straight**].
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

D. Mast Arms: [**Aluminum**] [**Steel**] [**Single-arm**] [**Truss**] [**Davit**] type, continuously welded to pole attachment plate. Material and finish same as plate.

E. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with [**stainless**] [**galvanized**]-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

F. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

G. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

H. Fasteners: [**Stainless steel**] [**Galvanized steel**] <**Insert finish or grade**>, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

I. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

K. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

L. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

M. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish

surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Powder coat shall comply with AAMA 2604.

    a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils (64- to 89-um) dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

## 2.4 FIBERGLASS POLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Poles:

1. Designed specifically for supporting luminaires, with factory-formed cable entrance and handhole.
2. Not less than 65 percent by weight of fiberglass roving, with resin and pigment making up the remainder.
3. Roving shall be continuously applied with uniform tension, with multiple layers placed to meet axial and compressive strength requirements.
4. Shape: [**Round, tapered**] [**Round, straight**] [**Square, tapered**] [**Square, straight**].
5. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
6. Resin Color: [**Black**] [**Dark**] [**Bronze**] <**Insert Color**>; uniform coloration throughout entire wall thickness.
7. Surface Finish: Smooth and uniform along surface of pole.
8. Paint Finish: Pigmented polyurethane, with a minimum dry film thickness of 1.5 mils (0.04 mm). Polyurethane may be omitted if the surface layer of the pole is inherently UV inhibited.

C. Mast Arms: [**Aluminum**] [**Steel**] [**Fiberglass**] [**Single-arm**] [**Truss**] [**Davit**] type, continuously welded to pole attachment plate. Material and finish same as plate. Adaptor plate shall be steel hot-dip galvanized according to ASTM A153 or 6061-T6 aluminum encased within fiberglass roving, allowing the mast arm adaptor to be bolted to the pole.

D. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting: Steel, hot-dip galvanized according to ASTM A153, or 6061-T6 aluminum, permanently bonded within fiberglass roving, allowing the bracket to be bolted to the pole-mounted adapter. Bolt together with [**stainless**] [**galvanized**]-steel bolts; use anti-seize compound when bolting dissimilar metals.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

E. Pole-Top Tenons: Steel, hot-dip galvanized according to ASTM A153, or 6061-T6 aluminum, permanently bonded to the fiberglass shaft. Fabricated to support luminaire or luminaires and brackets indicated.

F. Fasteners: [**Stainless steel**] [**Galvanized steel**] <**Insert finish or grade**>, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

G. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

H. Grounding: Bare, stranded copper, #6 AWG, [**suspended inside of pole**] [**inside a 3/4-inch (18-mm) conduit fastened to the interior of the pole**], connected to luminaire(s), ground lug near handhole and ground rod.

I. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

J. Anchor Base: Integral galvanized steel or aluminum casting, enclosing and permanently bonded to the exterior of the fiberglass shaft.

## 2.5 LAMINATED WOOD POLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Species and Grades for Structural Laminated Timber: Complying with ANSI A190.1. Use [**Southern pine**] [**Douglas fir**] [**Alaska cedar**] [**any species listed in AITC 117**], engineered and fabricated to withstand indicated structural loads without exceeding allowable design working stresses according to [**AITC 117**] [**ANSI O5.2**].

C. Features include [**wood bracket**] [**wood crossarm**] [**pole-top adaptor**] <**Insert items**> for mounting luminaire(s), metal pole cap, and concealed raceway path connected to access handhole.

D. Mounting Provisions: [**Embedded**] <**Insert description of other mounting unless detailed on Drawings**>.

E. Fasteners: [**Stainless steel**] [**Galvanized steel**] <**Insert finish or grade**>, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

F. Appearance Grade: Architectural appearance grade complying with AITC 110.

G. Preservative Treatment:

1. Exposure: Comply with [**AWPA UC4A**] [**AWPA UC4B**] [**AWPA UC4C**].
2. Treatment after Dressing and End Cutting: Comply with AWPA M4 for surface cuts to a depth of more than 1/16 inch (1.6 mm).

H. Adhesive: Wet-use type complying with ASTM D2559.

I. End Sealer: Manufacturer's standard, transparent, colorless wood sealer that is effective in retarding the transmission of moisture at cross-grain cuts and is compatible with indicated finish.

J. Penetrating Sealer: Manufacturer's standard, transparent, penetrating wood sealer that is compatible with indicated finish.

K. Finish: [**Natural, unstained wood**] [**Semitransparent stain applied after erection**] [**Factory-applied semitransparent stain**], color as selected by Architect.

## 2.6 WOOD POLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Poles: [**Douglas fir**] [**Southern yellow pine**], [**machine trimmed by turning,**] for wood species used; and bored, roofed, and grained before treatment.

1. Pole Brand: Brand the manufacturer's trademark and date of treatment, height and class of pole, wood species, preservation code, and retention. Brand shall be placed so that the bottom of the brand is minimum 10 feet (3 m) from pole butt.
2. Mounting Provisions: Embedded.

C. Fasteners: [**Stainless steel**] [**Galvanized steel**] <**Insert finish or grade**>, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

D. Preservative Treatment: Treat according to [**AWPA UC4A**] [**AWPA UC4B**] [**AWPA UC4C**].

E. Luminaire Brackets: Comply with ANSI C136.13.

## 2.7 PRESTRESSED CONCRETE POLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Poles: Comply with ASTM C1089[ **and manufactured by centrifugal spin-casting process**] [**and manufactured by static-casting method**].

1. Shape: [**Round, tapered**] [**Round, straight**] [**Square, tapered**] [**Square, straight**].
2. Mounting Provisions: [**Steel butt flange for bolted mounting to foundation or breakaway support**] [**Embedded**].
3. Finishing: Capped at top and plugged at bottom. Seat each reinforcing strand with epoxy adhesive.
4. Grounding: Continuous copper ground wire cast into pole. Terminate at top of pole[ **and attach to 24-inch (610-mm) lighting rod**].
5. Raceway: Smooth, internal, and not less than 3 inches (76 mm) in diameter.

C. Concrete: Minimum 28-day compressive strength of 7000 psi (48 265 kPa) <**Insert value**>.

D. Cured with wet steam and aged for a minimum of 15 days prior to installation.

E. Reinforcement: [**Reinforcing bars complying with ASTM A615/A615M**] [**Cold drawn spiral wire complying with ASTM A82**] [**Pre-stressing strand, 270 K, complying with ASTM A416/A416M**].

F. Surface Treatment: Hard, nonporous, and resistant to water, frost, and road and soil chemicals; and shall have a maximum water-absorption rate of 3 percent.

G. Finish Texture: [**Standard form**] [**Polished exposed aggregate**] [**Etched exposed aggregate**].

1. Exposed aggregate shall be of <**Insert aggregate type selected from manufacturers' lists**> type.

H. Fasteners: [**Stainless steel**] [**Galvanized steel**] <**Insert finish or grade**>, size and type as determined by manufacturer. Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

I. Nameplate: Aluminum cast into pole wall at approximately 5 feet (1.5 m) above ground line, listing name of manufacturer, Project identifier, overall height, and approximate weight.

J. Pole Brackets: Comply with ANSI C136.31.

## 2.8 POLE ACCESSORIES

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 262726 "Wiring Devices."

1. [**Surface mounted**] [**Recessed**] 12 inches (300 mm) <**Insert dimensions**> above finished grade.

a. NEMA 250, [**Type 3R**] [**Type 4X**], nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.
b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

D. Transformer-Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and to accept [**ballast(s)**] [**indicated accessories**]. Include removable flanged access cover secured with bolts or screws.

E. Decorative accessories, supplied by decorative pole manufacturer, include the following:

1. Banner Arms: <**Insert material**>.
2. Flag Holders: <**Insert material**>.
3. Ladder Rests: <**Insert material**>.

## 2.9 LOWERING SYSTEM FOR LUMINAIRES

A. System Description: Capable of lowering luminaire [**assembly** ]to a service position within 36 inches (900 mm) of finished grade in winds up to 30 mph (49 km/h). Provide manual plug connection to electrical power accessible in lowered position. Assembled system of pole, luminaire, and lowering device shall be capable of loads specified in "Performance Requirements" Article.

B. Compatibility of Material: Materials for attachment and connection of luminaire-mounting assembly, lowering device, lowering cable, and portable winch shall be compatible to avoid corrosion and electrolysis.

C. Structural and Mechanical Design Safety Factor: 5.0, minimum, for static and dynamic loads of load-bearing components, including cable.

D. Luminaire-Mounting and Disconnect Arrangement: Multiple [**ring**] [**carriage**]-mounted luminaires, arranged for lowering and rising as a group.

1. Electrical cable for normal operating power to luminaires shall manually disconnect inside pole base, using weatherproof multi-pin connector, and shall be arranged to move within the pole during lowering and rising of luminaire assembly.
2. Electrical cable for normal operating power to luminaires shall automatically disconnect at weatherproof multi-pin connector within the pole-top lowering head at the beginning of the lowering cycle and reconnect when luminaire or luminaire assembly is raised to the operating position.

E. Lowering Device: Weatherproof, cast-aluminum housing, and multiple mechanical latches. Moving parts of latching assembly shall be located in the portion of the unit that is lowered to servicing position. Positive latching in the operating position shall be indicated to the operator

at the base of the pole by a clear visual signal or by other means acceptable to Owner or authorities having jurisdiction.

F. Lowering Cable: [**Zinc-electroplated-**] [**or**] [**stainless-**] steel aircraft cable.

G. Portable Winch: [**Manual**] [**120-V electric**] type. [**One**] <**Insert number**> required.

1. Winch Power Connection: Cord and plug.
2. Winch Raise-Lower Control: Remote-control station with [**15 feet (5 m)**] <**Insert dimension**> of cable.

## 2.10 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to [**ASTM F1554, Grade 55,**] with a minimum yield strength of 55,000 psi (380 000 kPa).

1. Galvanizing: [**Hot dip galvanized according to ASTM A153, Class C**] [**Mechanically deposited galvanization according to ASTM B695, Class 50**].
2. [**Bent**] [**Headed**] rods <**Insert inches (mm)**> in diameter by <**Insert inches (mm)**> in length.
3. Threading: [**Uniform National Coarse**] [**Uniform National 8**], Class 2A.

B. Nuts: ASTM A563, Grade A, Heavy-Hex.

1. Galvanizing: [**Hot dip galvanized according to ASTM A153, Class C**] [**Mechanically deposited galvanization according to ASTM B695, Class 50**].
2. [**Two**] [**Four**] <**Insert number**> nuts provided per anchor bolt [**, shipped with nuts pre-assembled to the anchor bolts**].

C. Washers: ASTM F436, Type 1.

1. Galvanizing: [**Hot dip galvanized according to ASTM A153, Class C**] [**Mechanically deposited galvanization according to ASTM B695, Class 50**].
2. [**One**] [**Two**] <**Insert number**> washer(s) provided per anchor bolt.

## 2.11 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

### 3.2 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than [**one-sixth of pole height**] [**as indicated**]. Add backfill [**in 6-inch (150-mm) to 9-inch (230-mm) layers, tamping each layer before adding the next**] [**as shown on Drawings**] <**Insert requirement**>. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than [**one-sixth of pole height**] [**as indicated**]. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: Install plumb using manufacturer-supplied [**steel**] [**plywood**] template, uniformly spaced.

## 3.3 POLE INSTALLATION

A. Alignment: [**Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole**] [**Align poles as indicated**].

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: [**60 inches (1520 mm)**] <**Insert dimension**>.
2. Water, Gas, Electric, Communications, and Sewer Lines: [**10 feet (3 m)**] <**Insert dimension**>.
3. Trees: 15 feet (5 m) from tree trunk.
4. <**Insert features and clearance dimensions**>.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2 -inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-(150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

## 3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

## 3.5 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundation.

## 3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

## 3.7 FIELD QUALITY CONTROL

A. Special Inspections: [**Owner will engage**] [**Engage**] a qualified special inspector to perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.
2. System function tests.
3. <**Insert special inspections**>.

END OF SECTION 265613

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# SECTION 265619 – LED EXTERIOR LIGHTING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

### 1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.

3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

    a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

6. Wiring diagrams for power, control, and signal wiring.
7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

C. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

## 1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Sample warranty.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including luminaire support components.
b. Faulty operation of luminaires and accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. Lamp base complying with ANSI C81.61 or IEC 60061-1.

E. Bulb shape complying with ANSI C79.1.

F. CRI of minimum 80. CCT of 3000 K.

G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Internal driver.

J. Nominal Operating Voltage: 277 V ac.

K. In-line Fusing: Separate in-line fuse for each luminaire.

L. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

1. In Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
    a. Manufacturers: Subject to compliance with requirements, provide products by one the manufacturers specified.
2. Luminaire Shape: As noted on Lighting Fixture Schedule.
3. Mounting: As noted on Lighting Fixture Schedule.
4. Luminaire-Mounting Height: As noted on Lighting Fixture Schedule.
5. Distribution: As noted on Lighting Fixture Schedule.
6. Diffusers and Globes: As noted on Lighting Fixture Schedule.
7. Housings:

    a. Finish as noted on Lighting Fixture Schedule.

B. Bollard:
1. In Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
    a. Manufacturers: Subject to compliance with requirements, provide products by one the manufacturers specified.
2. Shape: As noted on Lighting Fixture Schedule.
3. Height Above Finished Grade: As noted on Lighting Fixture Schedule.
4. Overall Height: As noted on Lighting Fixture Schedule.
5. Diameter: As noted on Lighting Fixture Schedule.
6. Mounting: As noted on Lighting Fixture Schedule.
7. Distribution: As noted on Lighting Fixture Schedule.
8. Diffusers and Globes: As noted on Lighting Fixture Schedule.
9. Housings:

    a. Finish as noted on Lighting Fixture Schedule.

C. Canopy:
1. In Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
    a. Manufacturers: Subject to compliance with requirements, provide products by one the manufacturers specified
2. Shape: As noted on Lighting Fixture Schedule.
3. Dimensions: As noted on Lighting Fixture Schedule.
4. Diffusers and Globes: As noted on Lighting Fixture Schedule.
5. Housings:

    a. Finish as noted on Lighting Fixture Schedule.

## 2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Finish as noted on Lighting Fixture Schedule. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

E. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

F. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage and coating.
c. CCT and CRI for all luminaires.

## 2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Fasten luminaire to structural support.

D. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

E. Wiring Method: Install cables in raceways. Conceal raceways and cables.

F. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

G. Coordinate layout and installation of luminaires with other construction.

H. Adjust luminaires that require field adjustment or aiming.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.

3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.6 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

    a. IES LM-5.
    b. IES LM-50.
    c. IES LM-52.
    d. IES LM-64.
    e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

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

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

## 3.9 DEMONSTRATION

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

## 3.10 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to one visit to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

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# SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding rods.
5. Grounding labeling.

### 1.3 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. TGB: Telecommunications grounding busbar.

C. TMGB: Telecommunications main grounding busbar.

D. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

### 1.5 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:

1. Ground rods.
2. Ground and roof rings.

3. BCT, TMGB, TGBs, and routing of their bonding conductors.

B. Qualification Data: For [**Installer,** ]installation supervisor, and field inspector.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Result of the ground-resistance test, measured at the point of BCT connection.
b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.
c. <**Insert field quality-control test results**>.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS [**Technician**] [**Level 2 Installer**], who shall be present at all times when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as [**a designer RCDD**] [**Technician**] to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with TIA-607-B.

2.2 CONDUCTORS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Comply with UL 486A-486B.

C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: [**No. 8**] [**No. 6**] AWG.
3. <Double click to insert sustainable design text for lead content.>

D. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
2. Not smaller than No. 10 AWG and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

E. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: 28 kcmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

## 2.3 CONNECTORS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

D. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

E. Busbar Connectors: Cast silicon bronze, solderless [**compression**] [**or**] [**exothermic**]-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.

F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

## 2.4 GROUNDING BUSBARS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, [**1/4 by 4 inches (6.3 by 100 mm)**] <**Insert dimensions**> in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with TIA-607-B.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a [**4-inch (100-mm)**] <**Insert dimension**> clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. TGB: Predrilled rectangular bars of hard-drawn solid copper, [**1/4 by 2 inches (6.3 by 50 mm)**] <**Insert dimensions**> in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-B.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-B. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm) long, with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 GROUND RODS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Ground Rods: [**Copper-clad**] [**Zinc-coated**] [**Stainless-**] steel[**, sectional type**]; [**3/4 inch by 10 feet (19 mm by 3 m)**] [**5/8 by 96 inches (16 by 2400 mm)**] in diameter.

2.6 IDENTIFICATION

A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with TIA-607-B.

3.3 APPLICATION

A. Conductors: Install solid conductor for [**No. 8**] <**Insert number**> AWG and smaller and stranded conductors for [**No. 6**] <**Insert number**> AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than [**No. 6**] <**Insert number**> AWG.

2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than [**No. 6**] <**Insert number**> AWG.

B. Underground Grounding Conductors: Install bare [**tinned-**]copper conductor, [**No. 2**] <**Insert number**> AWG minimum.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches (900 mm).

E. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch (900-mm) intervals.
4. Install grounding and bonding conductors in 3/4-inch (21-mm) PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.

a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

## 3.4 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than [**No. 1/0**] [**No. 3/0**] <**Insert number**> AWG.

## 3.5 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.

B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

## 3.6 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than [**No. 6**] <**Insert number**> AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.

F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install [**top-mounted**] [**vertically mounted**] rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.

H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.

J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

K. Access Floors: Bond all metal parts of access floors to the TGB.

L. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using [**No. 6**] <**Insert number**> AWG bonding conductors.

1. Install the conductors in grid pattern on 4-foot (1200-mm) centers, allowing bonding of one pedestal from each access floor tile.
2. Bond the TGB of the equipment room to the reference grid at two or more locations.
3. Bond all conduits and piping entering the equipment room to the TGB at the perimeter of the room.

M. Towers and Antennas:

1. Ground Ring: Buried at least 30 inches (760 mm) below grade and at least 24 inches (610 mm) from the base of the tower or mounting.
2. Bond each tower base and metallic frame of a dish to the ground ring, buried at least 18 inches (460 mm) below grade.
3. Bond the ground ring and antenna grounds to the equipment room TMGB or TGB, buried at least 30 inches (760 mm) below grade.
4. Bond metallic fences within 6 feet (1.8 m) of towers and antennas to the ground ring, buried at least 18 inches (460 mm) below grade.
5. Special Requirements for Roof-Mounted Towers:

    a. Roof Ring: Meet requirements for the ground ring except the conductors shall comply with requirements in Section 264113 "Lightning Protection for Structures."
    b. Bond tower base footings steel, the TGB in the equipment room, and antenna support guys to the roof ring.
    c. Connect roof ring to the perimeter conductors of the lightning protection system.

6. Waveguides and Coaxial Cable:

    a. Bond cable shields at the point of entry into the building to the TGB and to the cable entrance plate, using No. 2 AWG bonding conductors.
    b. Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

N. <**Insert connections of other equipment**>.

## 3.7 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

B. Comply with IEEE C2 grounding requirements.

C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) extends above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

D. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

## 3.8 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.

1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

## 3.9 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB[ **and in each TGB**]. Maximum acceptable ac current level is 1 A.

D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds [**5**] <**Insert value**> ohms, notify Architect promptly and include recommendations to reduce ground resistance.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 270526

# SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Metallic surface pathways.
7. Nonmetallic surface pathways.
8. Tele-power poles.
9. Hooks.
10. Boxes, enclosures, and cabinets.
11. Polymer-concrete handholes and boxes for exterior underground cabling.
12. Fiberglass handholes and boxes for exterior underground cabling.

### 1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid conduit.

C. IMC: Intermediate metal conduit.

D. RTRC: Reinforced thermosetting resin conduit.

### 1.4 ACTION SUBMITTALS

A. Product data for the following:

1. Surface pathways
2. Wireways and fittings.
3. Tele-power poles.
4. Boxes, enclosures, and cabinets.

5. Underground handholes and boxes.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for adhesives and sealants.>

C. Shop Drawings: For custom enclosures and cabinets[ **and custom underground handholes and boxes**]. Include plans, elevations, sections, and attachment details.

D. Samples: For [**wireways**] [**nonmetallic wireways**] [**surface pathways**] [**and**] [**tele-power poles**] and for each color and texture specified, [**12 inches (300 mm)**] <**Insert dimension**> long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
3. Underground ducts, piping, and structures in location of underground enclosures and handholes.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: [**Seismic rating**] [**Provide seismic bracing**] for all pathway racks, enclosures, cabinets, equipment racks, and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

D. GRC: Comply with ANSI C80.1 and UL 6.

E. ARC: Comply with ANSI C80.5 and UL 6A.

F. IMC: Comply with ANSI C80.6 and UL 1242.

G. PVC-Coated Steel Conduit: PVC-coated [**GRC**] [**IMC**].

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

H. EMT: Comply with ANSI C80.3 and UL 797.

I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
2. Fittings for EMT:

a. Material: [**Steel**] [**or**] [**die cast**].
b. Type: [**Set screw**] [**or**] [**compression**].

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

J. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2. Comply with TIA-569-D.

D. RNC: [**Type EPC-40-PVC**] [**Type EPC-80-PVC**] <**Insert type**>, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. Rigid HDPE: Comply with UL 651A.

F. Continuous HDPE: Comply with UL 651A.

G. RTRC: Comply with UL 2515A and NEMA TC 14.

H. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

I. Solvents and Adhesives: As recommended by conduit manufacturer.

1. <Double click to insert sustainable design text for solvents and adhesives.>

## 2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for [**plenum**] [**riser**] [**or**] [**general-use**] installation unless otherwise indicated.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

## 2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal trough of rectangular cross section fabricated to required size and shape, without holes or knockouts, and with hinged or removable covers.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Metal Wireways and Auxiliary Gutters:

1. Comply with UL 870 and NEMA 250, [**Type 1**] [**Type 3R**] [**Type 4**] [**Type 12**] <**Insert type**> unless otherwise indicated, and sized according to NFPA 70.
2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D.

D. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Wireway Covers: [**Hinged type**] [**Screw-cover type**] [**Flanged-and-gasketed type**] unless otherwise indicated.

F. Finish: Manufacturer's standard enamel finish.

## 2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

B. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

C. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

F. Solvents and Adhesives: As recommended by conduit manufacturer.

1. <Double click to insert sustainable design text for solvents and adhesives.>

## 2.6 SURFACE METAL PATHWAYS

A. Description: Galvanized steel with snap-on covers, complying with UL 5.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Finish: [**Manufacturer's standard enamel finish in color selected by Architect**] [**Prime coated, ready for field painting**].

D. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

E. Comply with TIA-569-D.

2.7 SURFACE NONMETALLIC PATHWAYS:

A. Description: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Finish: Texture and color selected by Architect from [**manufacturer's standard**] [**custom**] colors.

D. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

E. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

F. Comply with TIA-569-D.

2.8 TELE-POWER POLES:

A. Description: Prefabricated, finished metal pole with prewired power and communications outlets.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Material: [**Galvanized steel with ivory baked-enamel finish**] [**Aluminum with clear anodized finish**].

D. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

E. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

F. Comply with TIA-569-D.

2.9 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

E. [**Galvanized**] [**stainless**] steel.

F. [**J**] [**U**] shape.

2.10 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: [**4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep)**] [**4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep)**] <**Insert other dimension**>.
5. Gangable boxes are [**allowed**] [**prohibited**].

D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, [**ferrous alloy**] [**aluminum**], Type FD, with gasketed cover.

F. Metal Floor Boxes:

1. Material: [**Cast metal**] [**or**] [**sheet metal**].
2. Type: [**Fully adjustable**] [**Semi-adjustable**].
3. Shape: Rectangular.
4. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, [**round**] [**rectangular**].

1. Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, [**cast aluminum**] [**galvanized, cast iron**] with gasketed cover.

J. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, [**Type 1**] [**Type 3R**] [**Type 4**] [**Type 12**] <**Insert type**>, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

    a. Material: [**Plastic**] [**Fiberglass**].
    b. Finished inside with radio-frequency-resistant paint.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. Cabinets:

1. NEMA 250, [**Type 1**] [**Type 3R**] [**Type 12**] <**Insert type**> galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.11 POLYMER-CONCRETE HANDHOLES

A. Description: Molded of sand and aggregate; bound together with polymer resin; and reinforced with steel, fiberglass, or a combination of the two.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Polymer Concrete Handholes:

1. Boxes and handholes for use in underground systems shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D[ **and SCTE 77**].

D. Configuration: Designed for flush burial with [**open**] [**closed**] [**integral closed**] bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

1. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
2. Cover Legend: Molded lettering, [**"COMMUNICATIONS"**] <**Insert legend**>.

F. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

G. Handholes [**12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long)**] <**Insert dimensions**> and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

## 2.12 FIBERGLASS HANDHOLES AND BOXES

A. Description: Molded of fiberglass-reinforced polyester resin, with frame and covers of [**polymer concrete**] [**reinforced concrete**] [**cast iron**] [**hot-dip galvanized-steel diamond plate**] [**fiberglass**].

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Fiberglass Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D[ **and SCTE 77**].

D. Color of Frame and Cover: [**Gray**] [**Green**].

E. Configuration: Designed for flush burial with [**open**] [**closed**] [**integral closed**] bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, [**"COMMUNICATIONS"**] <**Insert legend**>.

I. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

J. Handholes [**12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long)**] <**Insert dimensions**> and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

## 2.13 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.

2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

## PART 3 - EXECUTION

### 3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: [**GRC**] [**IMC**] [**RNC, Type EPC-40-PVC**] [**RNC, Type EPC-80-PVC**].
2. Concealed Conduit, Aboveground: [**GRC**] [**IMC**] [**EMT**] [**RNC, Type EPC-40-PVC**].
3. Underground Conduit: RNC, [**Type EPC-40-PVC**] [**Type EPC-80-PVC**], [**direct buried**] [**concrete encased**].
4. Boxes and Enclosures, Aboveground: NEMA 250, [**Type 3R**] [**Type 4**].

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: [**EMT**] [**or**] [**RNC**].
2. Exposed, Not Subject to Severe Physical Damage: [**EMT**] [**RNC identified for such use**].
3. Exposed and Subject to Severe Physical Damage: [**GRC**] [**IMC**]. Pathway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Gymnasiums
    e. <**Insert designations of applicable spaces or locations**>.

4. Concealed in Ceilings and Interior Walls and Partitions: [**EMT**] [**RNC, Type EPC-40-PVC**] [**or**] [**innerduct**].
5. Damp or Wet Locations: [**GRC**] [**IMC**].
6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: [**Plenum-type, optical-fiber-cable pathway**] [**Plenum-type, communications-cable pathway**] [**EMT**] <**Insert pathway type**>.
7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: [**Riser-type, optical-fiber-cable pathway**] [**Riser-type, communications-cable pathway**] [**EMT**] <**Insert pathway type**>.
8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: [**General-use, optical-fiber-cable pathway**] [**Riser-type, optical-fiber-cable pathway**] [**Plenum-type, optical-fiber-cable pathway**] [**General-use, communications-cable pathway**] [**Riser-type, communications-cable pathway**] [**Plenum-type, communications-cable pathway**] [**EMT**] <**Insert pathway type**>.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 [**stainless steel**] [**nonmetallic**] units in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use [**set-screw**] [**or**] [**compression**], [**steel**] [**cast-metal**] fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface pathways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds [**120 deg F (49 deg C)**] <**Insert temperature**>.

## 3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

D. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.

E. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.

F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

G. Complete pathway installation before starting conductor installation.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.

J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. Pathways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
3. Arrange pathways to keep a minimum of [**1 inch (25 mm)**] [**2 inches (50 mm)**] <**Insert dimension**> of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from nonmetallic conduit and fittings to [**RNC, Type EPC-40-PVC,**] [**GRC**] [**or**] [**IMC**] and fittings before rising above floor.

M. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

Q. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.

R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

S. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

T. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

U. Surface Pathways:

1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
2. Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

V. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
2. 1-Inch (25-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

W. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

X. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

Y. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

Z. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC[ **and EMT**] that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: [**125 deg F (70 deg C)**] <**Insert temperature**> temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: [**155 deg F (86 deg C)**] <**Insert temperature**> temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: [**125 deg F (70 deg C)**] <**Insert temperature**> temperature change.
    d. Attics: [**135 deg F (75 deg C)**] <**Insert temperature**> temperature change.
    e. <**Insert location and corresponding temperature change**>.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

AA. Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
4. Space hooks no more than 5 feet (1.5 m) o.c.
5. Provide a hook at each change in direction.

BB. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to [**center**] [**top**] [**bottom**] of box unless otherwise indicated.

CC. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

DD. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

GG. Set metal floor boxes level and flush with finished floor surface.

HH. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

## 3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe of less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete around conduit for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 270553 "Identification for Communications Systems."

## 3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install handholes with bottom below frost line, <**Insert depth of frost line below grade at Project site**> below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

## 3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

## 3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

## 3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

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# SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems for communication raceways.
2. Aluminum slotted support systems for communication raceways.
3. Nonmetallic slotted support systems for communication raceways.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 270548 "Seismic Controls for Communications Systems" for products and installation requirements necessary for compliance with seismic criteria.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

j. <**Insert product type**>.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings:[ **Signed and sealed by a qualified professional engineer.**] For fabrication and installation details for communications hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Aluminum slotted-channel systems.
4. Nonmetallic slotted-channel systems.
5. Equipment supports.
6. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for communications systems.

1. Include design calculations and details of trapeze hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Projectors.
g. <**Insert item**>.

B. Seismic Qualification Data: Certificates, for hangers and supports for communications equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to [**AWS D1.1/D1.1M**] [**AWS D1.2/D1.2M**].

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified[ **and the system will be fully operational after the seismic event**]."
2. Component Importance Factor: [**1.5**] [**1.0**].
3. <**Insert requirements for Component Amplification Factor and Component Response Modification Factor**>.

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.

3. Material for Channel, Fittings, and Accessories: [**Galvanized steel**] [**Plain steel**] [**Stainless Steel, Type 304**] [**Stainless Steel, Type 316**].
4. Channel Width: [**Selected for applicable load criteria**] [**1-5/8 inches (41.25 mm)**] [**1-1/4 inches (31.75 mm)**] [**13/16 inches (20.64 mm)**] <**Insert size**>.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
9. Channel Dimensions: Selected for applicable load criteria.

B. Aluminum Slotted Support Systems: Extruded aluminum channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channel Material: 6063-T6 aluminum alloy.
4. Fittings and Accessories Material: 5052-H32 aluminum alloy.
5. Channel Width: [**Selected for applicable load criteria**] [**1-5/8 inches (41.25 mm)**] [**1-1/4 inches (31.75 mm)**] [**13/16 inches (20.64 mm)**] <**Insert size**>.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
9. Channel Dimensions: Selected for applicable load criteria.

C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least one surface.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channel Width: [**Selected for applicable load criteria**] [**1-5/8 inches (41.25 mm)**] [**1-1/4 inches (31.75 mm)**] [**13/16 inches (20.64 mm)**] <**Insert size**>.
4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
5. Fitting and Accessory Materials: Same as those for channels and angles[**, except metal items may be stainless steel**].
6. Rated Strength: Selected to suit applicable load criteria.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

D. Conduit and Cable Support Devices: [**Steel**] [**Steel and malleable-iron**] [**Stainless-steel**] [**Glass-fiber-resin**] clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Mechanical-Expansion Anchors: Insert-wedge-type [**zinc-coated steel**] [**stainless steel**] for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M,Grade A325 (Grade A325M).
6. Toggle Bolts: [**All-steel**] [**Stainless-steel**] springhead type.
7. Hanger Rods: Threaded steel.

## 2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101.
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as [**required by**] [**scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in**] NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted [**or other** ]support system, sized so capacity can be increased by at least [**25**] <**Insert number**> percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with [**two-bolt conduit clamps**] [**single-bolt conduit clamps**] [**single-bolt conduit clamps, using spring friction action for retention in support channel**].

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Raceway Support Methods: In addition to methods described in NECA 1, [**EMT**] [**IMC**] [**and**] [**RMC**] may be supported by openings through structure members, according to NFPA 70.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Use expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: [**Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts**] [**Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69**] [**Spring-tension clamps**].
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate[ **by means that comply with seismic-restraint strength and anchorage requirements**].

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

## 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor communications materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

## 3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in [**Section 099113 "Exterior Painting"**] [**Section 099123 "Interior Painting"**] [**and**] [**Section 099600 "High-Performance Coatings"**] <**Insert other**

**painting Sections**> for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 270529

# SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
   1. Wire-mesh cable tray.
   2. Cable tray accessories.
   3. Warning signs.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

   1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

   1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
   2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

      a. Vertical and horizontal offsets and transitions.
      b. Clearances for access above and to sides of cable trays.
      c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
      d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated-Design Submittal: For seismic restraints.

   1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.
   3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.
4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Seismic Qualification Data: Certificates, for cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: [**1.5**] [**1.0**].
3. <**Insert requirements for Component Amplification Factor and Component Response Modification Factor**>.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: [**120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces**] <**Insert temperature change**>.

## 2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

## 2.3 LADDER CABLE TRAY

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: [**6 inches (150 mm)**] [**9 inches (225 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] [**24 inches (600 mm)**] [**30 inches (750 mm)**] [**36 inches (900 mm)**] unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: [**3 inches (75 mm)**] [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**6 inches (150 mm)**].
4. Straight Section Lengths: [**10 feet (3.0 m)**] [**12 feet (3.7 m)**] [**20 feet (6.0 m)**] [**24 feet (7.4 m)**], except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: [**6 inches (150 mm)**] [**9 inches (225 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] o.c.
6. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
8. No portion of the rungs shall protrude below the bottom plane of side rails.
9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: [**12 inches (300 mm)**] [**24 inches (600 mm)**] [**36 inches (900 mm)**] [**48 inches (1200 mm)**].
11. Class Designation: Comply with NEMA VE 1, [**Class 5AA**] [**Class 5A**] [**Class 8AA**] [**Class 8A**] [**Class 10AA**] [**Class 10A**] [**Class 12AA**] [**Class 12A**] [**Class 20AA**] [**Class 20A**] <**Insert designation**>.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.

13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
14. Covers: [**Solid**] [**Louvered**] [**Ventilated-hat**] [**2-in-3 pitch**] type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of [**ASTM A1011/A1011M, SS, Grade 33**] [**ASTM A1008/A1008M, Grade 33, Type 2**].
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

1) Hardware: [**Galvanized, ASTM B633**] [**Chromium-zinc plated, ASTM F1136**] [**Stainless steel, Type 316**].

e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: [**Galvanized, ASTM B633**] [**Chromium-zinc plated, ASTM F1136**].

f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

1) Hardware: Galvanized, ASTM B633.

g. Finish: [**Epoxy-resin**] [**Powder-coat enamel**] paint.

1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
4) Hardware: [**Chromium-zinc plated, ASTM F1136**] [**Stainless steel, Type 316, ASTM F593 and ASTM F594**].

h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F1136.
i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D769.
j. <**Insert finish**>.

2. Aluminum:

a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and [**Alloy 5052-H32**] [**or**] [**Alloy 6061-T6**] according to ANSI H35.1/H 35.1M for fabricated parts.
b. Hardware: [**Chromium-zinc-plated steel, ASTM F1136**] [**Stainless steel, Type 316, ASTM F593 and ASTM F594**].
c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

3. Stainless Steel:

a. Materials: Low-carbon, passivated stainless steel, [**Type 304L**] [**or**] [**Type 316L**], ASTM F593 and ASTM F594.
b. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

## 2.4 WIRE-MESH CABLE TRAY

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. Configuration: [**Galvanized-**] steel wire mesh, complying with NEMA VE 1.
2. Width: [**2 inches (50 mm)**] [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**] [**20 inches (500 mm)**] [**24 inches (600 mm)**] unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: [**1 inch (25 mm)**] [**2 inches (50 mm)**] [**4 inches (100 mm)**] [**6 inches (150 mm)**].
4. Straight Section Lengths: [**10 feet (3.0 m)**] [**12 feet (3.7 m)**], except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
6. Class Designation: Comply with NEMA VE 1, [**Class 5AA**] [**Class 5A**] [**Class 8AA**] [**Class 8A**] [**Class 10AA**] [**Class 10A**] [**Class 12AA**] [**Class 12A**] [**Class 20AA**] [**Class 20A**] <**Insert designation**>.
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of [**ASTM A1011/A1011M, SS, Grade 33**] [**ASTM A1008/A1008M, Grade 33, Type 2**].
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.

c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

1) Hardware: [**Galvanized, ASTM B633**] [**Chromium-zinc plated, ASTM F1136**] [**Stainless steel, Type 316**].

e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: [**Galvanized, ASTM B633**] [**Chromium-zinc plated, ASTM F1136**].

f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

1) Hardware: Galvanized, ASTM B633.

g. Finish: [**Epoxy-resin**] [**Powder-coat enamel**] paint.

1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
4) Hardware: [**Chromium-zinc plated, ASTM F1136**] [**Stainless steel, Type 316, ASTM F593 and ASTM F594**].

h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F1136.
i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D769.
j. <**Insert finish**>.

## 2.5 SINGLE-RAIL CABLE TRAY

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. Configuration: An extruded-aluminum assembly, consisting of a single longitudinal center rail with transverse rungs arranged symmetrically about the center rail complying with NEMA VE 1.
2. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
3. Width: [**6 inches (150 mm)**] [**9 inches (225 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] [**24 inches (600 mm)**] unless otherwise indicated on Drawings.
4. Minimum Usable Load Depth: [**3 inches (75 mm)**] [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**6 inches (150 mm)**].

5. Straight Section Lengths: [**10 feet (3.0 m)**] [**12 feet (3.7 m)**], except where shorter lengths are required to facilitate tray assembly.
6. Rung Spacing: [**6 inches (150 mm)**] [**9 inches (225 mm)**] [**12 inches (300 mm)**] o.c.
7. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
8. Support Point: Splice fittings shall be hanger support point.
9. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
10. Class Designation: Comply with NEMA VE 1, [**Class 5AA**] [**Class 5A**] [**Class 8AA**] [**Class 8A**] [**Class 10AA**] [**Class 10A**] [**Class 12AA**] [**Class 12A**] [**Class 20AA**] [**Class 20A**] <**Insert designation**>.
11. Unbalanced Loads: Maintain cable tray rungs within six degrees of horizontal under all loading conditions.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
14. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.
15. Covers: [**Solid**] [**Louvered**] [**Ventilated-hat**] [**2-in-3 pitch**] type made of same materials and with same finishes as cable tray.

C. Materials: Aluminum alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and [**Alloy 5052-H32**] [**or**] [**Alloy 6061-T6**] according to ANSI H35.1/H 35.1M for fabricated parts.

D. Hardware: [**Chromium-zinc-plated steel, ASTM F1136**] [**Stainless steel, Type 316, ASTM F593 and ASTM F594**].

E. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

## 2.6 TROUGH CABLE TRAY

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. Configuration:

   a. A [**flat**] [**corrugated**] bearing surface with a [**solid**] [**ventilated**] bottom contained within two longitudinal side rails, with both edges welded to the side rails complying with NEMA VE 1.
   b. Single, formed sheet with a [**solid**] [**ventilated**] bottom, complying with NEMA VE 1.

2. Covers: [**Solid**] [**Louvered**] [**Ventilated-hat**] [**2-in-3 pitch**] type made of same materials and with same finishes as cable tray.

3. Width: [**6 inches (150 mm)**] [**9 inches (225 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] [**24 inches (600 mm)**] [**30 inches (750 mm)**] [**36 inches (900 mm)**] unless otherwise indicated on Drawings.
4. Minimum Usable Load Depth: [**3 inches (75 mm)**] [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**6 inches (150 mm)**].
5. Straight Section Lengths: [**10 feet (3.0 m)**] [**12 feet (3.6 m)**] [**20 feet (6.0 m)**] [**24 feet (7.4 m)**], except where shorter lengths are required to facilitate tray assembly.
6. Fitting Minimum Radius: [**12 inches (300 mm)**] [**24 inches (600 mm)**] [**36 inches (900 mm)**] [**48 inches (1200 mm)**].
7. Class Designation: Comply with NEMA VE 1, [**Class 5AA**] [**Class 5A**] [**Class 8AA**] [**Class 8A**] [**Class 10AA**] [**Class 10A**] [**Class 12AA**] [**Class 12A**] [**Class 20AA**] [**Class 20A**] <**Insert designation**>.
8. Splicing Assemblies: Bolted type using serrated flange locknuts.
9. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
10. Covers: [**Solid**] [**Louvered**] [**Ventilated-hat**] [**2-in-3 pitch**] type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of [**ASTM A1011/A1011M, SS, Grade 33**] [**ASTM A1008/A1008M, Grade 33, Type 2**].
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2.

1) Hardware: [**Galvanized, ASTM B633**] [**Chromium-zinc plated, ASTM F1136**] [**Stainless steel, Type 316**].

e. Finish: Hot-dip mill galvanized before fabrication complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: [**Galvanized, ASTM B633**] [**Chromium-zinc plated, ASTM F1136**].

f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

1) Hardware: Galvanized, ASTM B633.

g. Finish: [**Epoxy-resin**] [**Powder-coat enamel**] paint.

1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.

3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
4) Hardware: [**Chromium-zinc plated, ASTM F1136**] [**Stainless steel, Type 316, ASTM F593 and ASTM F594**].

h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F1136.
i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D769.
j. <**Insert finish**>.

2. Aluminum:

a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and [**Alloy 5052-H32**] [**or**] [**Alloy 6061-T6**] according to ANSI H35.1/H 35.1M for fabricated parts.
b. Hardware: [**Chromium-zinc-plated steel, ASTM F1136**] [**Stainless steel, Type 316, ASTM F593 and ASTM F594**].
c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

3. Stainless Steel:

a. Materials: Low-carbon, passivated stainless steel, [**Type 304L**] [**or**] [**Type 316L**], ASTM F593 and ASTM F594.
b. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

## 2.7 FIBERGLASS CABLE TRAY

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. Configuration: Two longitudinal members with rounded edges and smooth surfaces, supporting a bearing surface, complying with NEMA FG 1.
2. Materials: Straight section structural elements; side rails, rungs, and splice plates shall be pultruded from glass-fiber-reinforced [**polyester**] [**vinyl ester**] resin, complying with NEMA FG 1 and UL 568.
3. Width: [**6 inches (150 mm)**] [**9 inches (225 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] [**24 inches (600 mm)**] [**30 inches (750 mm)**] [**36 inches (900 mm)**] unless otherwise indicated on Drawings.
4. Minimum Usable Load Depth: [**1 inch (25 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**] [**5 inches (125 mm)**] [**7 inches (175 mm)**] according to NEMA FG 1.
5. Straight Section Lengths: [**10 feet (3.0 m)**] [**20 feet (6.0 m)**].
6. Class Designation: Comply with NEMA VE 1, [**Class 5AA**] [**Class 5A**] [**Class 8AA**] [**Class 8A**] [**Class 10AA**] [**Class 10A**] [**Class 12AA**] [**Class 12A**] [**Class 20AA**] [**Class 20A**] <**Insert designation**>.

7. Temperature Rating: Reduce the load rating of trays exposed to temperatures above 75 deg F (24 deg C) according to Table 4-3, "Working Loads," in NEMA FG 1.
8. Fitting Minimum Radius: [**12 inches (300 mm)**] [**24 inches (600 mm)**].
9. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates shall be furnished with straight sections and fittings.
10. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
11. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
12. Covers: [**Solid**] [**Louvered**] [**Ventilated-hat**] [**2-in-3 pitch**] type made of same materials and with same finishes as cable tray.

## 2.8 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

## 2.9 WARNING SIGNS

A. Comply with requirements for identification in Section 270553 "Identification for Communications Systems."

B. Lettering: [**1-1/2-inch- (40-mm-)**] <**Insert dimension**> high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

## 2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to [**NEMA FG 1**] [**NEMA VE 1**].

# PART 3 - EXECUTION

## 3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to [**NEMA FG 1**] [**NEMA VE 2**].

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

F. Fasten cable tray supports to building structure[ **and install seismic restraints**].

G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems."[ **Comply with seismic-restraint details according to Section 270548.16 "Seismic Controls for Communications Systems."**]

H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support bus assembly to prevent twisting from eccentric loading.

K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

L. Locate and install supports according to [**NEMA FG 1**] [**NEMA VE 2**]. Do not install more than one cable tray splice between supports.

M. Support wire-basket cable trays with [**center support hangers**] [**trapeze hangers**] [**wall brackets**].

N. Support [**center support hangers**] [**trapeze hangers**] for wire-basket trays with [**1/4-inch- (6-mm-)**] [**3/8-inch- (10-mm-)**] diameter rods.

O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in [**NEMA FG 1**] [**NEMA VE 2**]. Space connectors and set gaps according to applicable standard.

Q. Make changes in direction and elevation using manufacturer's recommended fittings.

R. Make cable tray connections using manufacturer's recommended fittings.

S. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

U. Install cable trays with enough workspace to permit access for installing cables.

V. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

W. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

X. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

Y. Install warning signs in visible locations on or near cable trays after cable tray installation.

## 3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch (1800-mm) intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

## 3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).

E. Tie MI cables down every 36 inches (900 mm) where required to provide a 2-hour fire rating and every 72 inches (1800 mm) elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

## 3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

## 3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections[ **with the assistance of a factory-authorized service representative**]:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

# SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for paints and coatings.>

## PART 2 - PRODUCTS

### 2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized-steel sheet.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

## 2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Sealing Elements: [**EPDM**] [**Nitrile (Buna N)**] rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: [**Carbon steel**] [**Plastic**] [**Stainless steel**].
4. Connecting Bolts and Nuts: [**Carbon steel, with corrosion-resistant coating,**] [**Stainless steel**] of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. <Double click to insert sustainable design text for sealants.>

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide [**1/4-inch (6.4-mm)**] <**Insert dimension**> annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed[ **or unless seismic criteria require different clearance**].
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors [**2 inches (50 mm)**] <**Insert dimension**> above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using [**steel**] [**cast-iron**] pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

## 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

## 3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 270544

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# SECTION 270548.16 - SEISMIC CONTROLS FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 270528.29 "Hangers and Supports for Communications Systems" for commonly used supports and installation requirements.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].
b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic[ **and wind**] forces required to select seismic[ **and wind**] restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic[**- and Wind**]-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic[ **and wind**] restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
    d. Preapproval and Evaluation Documentation: By [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**], showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Communications components include:

1. Uninterruptible power supplies.
2. Racks.
3. Frames.
4. Cabinets.
5. Cable tray.
6. Conduits.

B. Qualification Data: For [**professional engineer**] [**and**] [**testing agency**].

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: <**Insert value**>.
2. Building Classification Category: [**I**] [**II**] [**III**] [**IV**].
3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: [**A**] [**B**] [**C**] [**D**] [**E**] [**F**].
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [**I**] [**II**] [**III**].

    a. Component Importance Factor: [**1.0**] [**1.5**] <**Insert value**>.
    b. Component Response Modification Factor: [**1.5**] [**2.5**] [**3.5**] [**5.0**] <**Insert value**>.
    c. Component Amplification Factor: [**1.0**] [**2.5**] <**Insert value**>.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): <**Insert percentage**>.
4. Design Spectral Response Acceleration at 1.0-Second Period: <**Insert percentage**>.

2.2 RESTRAINT CHANNEL BRACINGS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Restraint Cables: [**ASTM A603 galvanized**] [**ASTM A492 stainless**]-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Hanger-Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to [**rigid channel bracings**] [**and**] [**restraint cables**].

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.6 ADHESIVE ANCHOR BOLTS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive [**vibration isolation and** ]seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

## 3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

## 3.5 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections[ **with the assistance of a factory-authorized service representative**]:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least [**four**] <**Insert number**> of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 270548.16

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# SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes.
5. Signs.
6. Cable ties.
7. Fasteners for labels and signs.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70 and TIA 606-B.

B. Comply with ANSI Z535.4 for safety signs and labels.

C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: [**120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces**] <**Insert temperature change**>.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Equipment Identification Labels:

1. Black letters on a white field.
2. <**Insert specific requirements for equipment to be labeled, such as racks, cabinets, etc.**>.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Self-Adhesive Wraparound Labels: [**Preprinted**] [**Write-on**], 3-mil- (0.08-mm-) thick, [**polyester**] [**vinyl**] flexible labels with acrylic pressure-sensitive adhesive.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

3. Marker for Labels: Permanent, waterproof black ink marker recommended by tag manufacturer.
4. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: [**Polyester**] [**Vinyl**], thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Minimum Nominal Size:

a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
c. As required by authorities having jurisdiction.

## 2.4 BANDS AND TUBES

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.5 UNDERGROUND-LINE WARNING TAPE

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

C. Color and Printing:

1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE" <**Insert inscription**>.

D. Tag: [**Type I**] <**Insert drawing designation**>:

1. Pigmented polyolefin, bright colored, [**continuous-printed on one side with the inscription of the utility,** ]compounded for direct-burial service.
2. Width: 3 inches (75 mm).

3. Thickness: 4 mils (0.1 mm).
4. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
5. Tensile according to ASTM D882: 30 lbf (133.4 N) and 2500 psi (17.2 MPa).

E. Tag: [**Type II**] <**Insert drawing designation**>:

1. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, [**continuous-printed on one side with the inscription of the utility,** ]compounded for direct-burial service.
2. Width: 3 inches (75 mm).
3. Thickness: 12 mils (0.3 mm).
4. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).
5. Tensile according to ASTM D882: 400 lbf (1780 N) and 11,500 psi (79.2 MPa).

F. Tag: [**Type ID**] <**Insert drawing designation**>:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, [**continuous-printed on one side with the inscription of the utility,** ]compounded for direct-burial service.
2. Width: 3 inches (75 mm).
3. Overall Thickness: 5 mils (0.125 mm).
4. Foil Core Thickness: 0.35 mil (0.00889 mm).
5. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
6. Tensile according to ASTM D882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

G. Tag: [**Type IID**] <**Insert drawing designation**>:

1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, [**continuous-printed on one side with the inscription of the utility,** ]compounded for direct-burial service.
2. Width: 3 inches (75 mm).
3. Overall Thickness: 8 mils (0.2 mm).
4. Foil Core Thickness: 0.35 mil (0.00889 mm).
5. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
6. Tensile according to ASTM D882: 300 lbf (1334 N) and 12,500 psi (86.1 MPa).

## 2.6 SIGNS

A. Baked-Enamel Signs:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Preprinted aluminum signs, [**high-intensity reflective,** ]punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Metal-Backed Butyrate Signs:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 10 by 14 inches (250 by 360 mm).

C. Laminated-Acrylic or Melamine-Plastic Signs:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Engraved legend.
3. Thickness:

    a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
    b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
    c. Engraved legend with [**black letters on white face**] [**white letters on a dark gray background**] <**Insert colors**>.
    d. [**Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting**] [**Self-adhesive**].
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

## 2.7 CABLE TIES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 7000 psi (48.2 MPa).

3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

## 2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

## 3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.

G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

H. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
3. Provide label 6 inches (150 mm) from cable end.

I. Snap-Around Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches (150 mm) from cable end.

J. Self-Adhesive Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches (150 mm) from cable end.

K. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [**or concrete envelope** ]exceeds 16 inches (400 mm) overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

## 3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.

1. System legends shall be as follows:

a. Telecommunications.
b. <**Insert name**>.

D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation[**, numbered clockwise when entering room from primary egress**], composed of the following, in the order listed:

1. Wiring closet designation.
2. Colon.
3. Faceplate number.

E. Equipment Room Labeling:

1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels[ **containing equipment designation**].
2. Patch Panels: [**Label individual rows in each rack, starting at top and working down, with self-adhesive labels.**] [**Label individual rows and outlets, starting at to left and working down, with self-adhesive labels.**]
3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:

a. Room number being served.
b. Colon.
c. Faceplate number.

F. Backbone Cables: Label each cable with a [**vinyl-wraparound label**] [**snap-around label**] [**self-adhesive wraparound label**] indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.

G. Horizontal Cables: Label each cable with a [**vinyl-wraparound label**] [**snap-around label**] [**self-adhesive wraparound label**] indicating the following, in the order listed:

1. Room number.
2. Colon.
3. Faceplate number.

H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.

I. Instructional Signs: Self-adhesive labels.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: [**Self-adhesive labels**] [**Baked-enamel warning signs**] [**Metal-backed, butyrate warning signs**].

1. Apply to exterior of door, cover, or other access.

K. Equipment Identification Labels:

1. Indoor Equipment: [**Self-adhesive label**] [**Baked-enamel signs**] [**Metal-backed butyrate signs**] [**Laminated-acrylic or melamine-plastic sign**].
2. Outdoor Equipment: [**Laminated-acrylic or melamine-plastic sign**] [**Stenciled legend 4 inches (100 mm) high**].
3. Equipment to Be Labeled:

a. Communications cabinets.
b. Uninterruptible power supplies.
c. Computer room air conditioners.
d. Fire-alarm and suppression equipment.
e. Egress points.
f. Power distribution components.
g. <**Insert equipment**>.

END OF SECTION 270553

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# SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Backboards.
2. Boxes, enclosures, and cabinets.
3. Power strips.

B. Related Requirements:

1. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
2. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
3. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
4. Section 271333 "Communications Coaxial Backbone Cabling" for coaxial data cabling associated with system panels and devices.
5. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.
6. Section 271523 "Communications Optical Fiber Horizontal Cabling" for coaxial data cabling associated with system panels and devices.
7. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial data cabling associated with system panels and devices.

### 1.3 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. BICSI: Building Industry Consulting Service International.

C. RCDD: Registered communications distribution designer.

D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

E. TGB: Telecommunications grounding bus bar.

F. TMGB: Telecommunications main grounding bus bar.

## 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**Installer,** ]qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Data: Certificates, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of [**RCDD**] [**Technician**].

2. Installation Supervision: Installation shall be under direct supervision of [**Technician**] [**Installer 2, Copper or Fiber**], who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as [**RCDD**] [**Technician**] to perform the on-site inspection.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] [**Telcordia GR-63-CORE requirements for Zone 4 Seismic Earthquake Environments**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[ **and the unit will be fully operational after the seismic event**]."

### 2.2 BACKBOARDS

A. Backboards: Plywood, [**fire-retardant treated,** ]3/4 by 48 by 96 inches (19 by 1220 by 2440 mm).

B. Backboard Paint: [**Pre-painted**] [**Light-colored fire-retardant paint**] [**Light-colored interior latex paint**].

### 2.3 BOXES, ENCLOSURES, AND CABINETS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed and labeled for intended location and use.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, Type FD, [**ferrous alloy**] [**aluminum**], with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, [**cast aluminum**] [**galvanized cast iron**] with gasketed cover.

H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

I. Device Box Dimensions: [**4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep)**] [**4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep)**] <**Insert dimension**>.

J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, [**Type 1**] [**Type 3R**] [**Type 4**] [**Type 12**] <**Insert type**> with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: [**Plastic**] [**Fiberglass**].
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

K. Cabinets:

1. NEMA 250, [**Type 1**] [**Type 3R**] [**Type 12**] <**Insert type**> galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.4 POWER STRIPS

A. Comply with requirements in Section 271116 "Communications Racks, Frames, and Enclosures."

B. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting, with [**detachable**] [**integral**] flanges.
3. Height: [**1 RU**]. <**Insert value**>.
4. Housing: [**Metal**] <**Insert material**>.
5. [**Six**] <**Insert number**>, [**15-A, 120-V ac, NEMA WD 6, Configuration 5-15R**] [**20-A, 120-V ac, NEMA WD 6, Configuration 5-20R**] receptacles.
6. [**Front**] [**Rear**]-facing receptacles.
7. LED indicator lights for power and protection status.
8. LED indicator lights for reverse polarity and open outlet ground.
9. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
10. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
11. [**Close-coupled, direct plug-in**] [**Cord connected with 15-foot (4.5-m)**] line cord.

12. Rocker-type on-off switch, illuminated when in on position.
13. Surge Protection: UL 1449, Type 3.

    a. Maximum Surge Current, Line to Neutral: [**27 kA**] [**72 kA**] <**Insert value**>.
    b. Protection modes shall be line to neutral, line to ground, and neutral to ground.
    c. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall be [**600 V**] <**Insert value**> and [**500 V**].<**Insert value**> for neutral to ground.

## PART 3 - EXECUTION

### 3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for materials and installation requirements for [**underground**] [**buried**] [**aerial**] pathways.

### 3.2 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in communications equipment spaces.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Coordinate layout and installation of communications equipment in tracks and in room. Coordinate service entrance configuration with service provider.

1. Meet jointly with systems providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize configurations and space requirements of communications equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

G. Backboards:

1. Install from 6 inches (150 mm) to 8 feet, 6 inches (2588 mm) above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
2. Paint all sides of backboard with two coats of paint[**, leaving fire rating stamp visible**].
3. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.

## 3.3 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

## 3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual," "Firestopping Practices" Ch.

END OF SECTION 271100

# SECTION 271116 - COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. 19-inch equipment racks.
2. 23-inch equipment racks.
3. 19-inch [**freestanding**] [**wall-mounted**] [**freestanding and wall-mounted**] equipment cabinets.
4. 23-inch [**freestanding**] [**wall-mounted**] [**freestanding and wall-mounted**] equipment cabinets.
5. Open Rack equipment racks.
6. Power strips.
7. Grounding.
8. Labeling.

B. Related Requirements:

1. Section 271110 "Communications Equipment Room Fittings" for backboards and accessories.
2. Section 270526 "Grounding and Bonding for Telecommunications Equipment" for TMGBs and TGBs.
3. Section 270536 "Cable Trays for Communications Systems" for cable trays and cable tray accessories.
4. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
5. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
6. Section 271333 "Communications Coaxial Backbone Cabling" for coaxial data cabling associated with system panels and devices.
7. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.
8. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical-fiber data cabling associated with system panels and devices.
9. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial data cabling associated with system panels and devices.
10. Section 271611 "Communications Hybrid Cabling" for combined copper and optical fiber data cables associated with system panels and devices.

1.3 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. BICSI: Building Industry Consulting Service International.

C. LAN: Local area network.

D. RCDD: Registered communications distribution designer.

E. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

F. TGB: Telecommunications grounding bus bar.

G. TMGB: Telecommunications main grounding bus bar.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
2. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.

B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**Installer,** ]qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Data: Certificates, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of [**RCDD**] [**Technician**].
2. Installation Supervision: Installation shall be under direct supervision of [**Technician**] [**Installer 2, Copper or Fiber**], who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as [**RCDD**] [**Technician**] to perform on-site inspection.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] [**Telcordia GR-63-CORE requirements for Zone 4 Seismic Earthquake Environments**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[ **and the unit will be fully operational after the seismic event**]."

B. UL listed.

C. RoHS compliant.

D. Compliant with requirements of the Payment Card Industry Data Security Standard.

## 2.2 BACKBOARDS

A. Backboards: Plywood, [**fire-retardant treated,** ]3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."

## 2.3 19-INCH EQUIPMENT RACKS

A. Description: [**Two-**] [**and**] [**four-**] post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72-inches (450-mm) between rails.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements:

1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: [**Extruded steel**] [**Extruded aluminum**] [**Sheet steel**] [**Sheet aluminum**].
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: [**Black**] <**Insert color**>.

D. Floor-Mounted Racks:

1. Overall Height: [**72 inches (1828.8 mm)**] [**84 inches (2133.6 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Overall Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Upright Depth: [**3 inches (76.2 mm)**] [**6 inches (152.4 mm)**] <**Insert value**>.
4. Two-Post Load Rating: [**200 lb (91 kg)**] [**400 lb (181 kg)**] <**Insert value**>.
5. Four-Post Load Rating: [**1000 lb (454 kg)**] [**2000 lb (907 kg)**] <**Insert value**>.
6. Number of Rack Units per Rack: [**38**] [**42**] [**45**] [**52**] [**58**] [**As indicated on Drawings**] <**Insert number**>.

    a. Numbering: [**Every**] [**Every five**] rack units, on interior of rack.

7. Threads: [**10-32**] [**12-24**] [**Universal square**].
8. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug[**, and a power strip**].
9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
10. Top shall have provisions for attaching to cable tray or ceiling.
11. Self-leveling.

E. Wall-Mounted Racks:

1. Height: [**18 inches (457.2 mm)**] [**22 inches (558.8 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Load Rating: [**150 lb (65 kg)**] [**200 lb (91 kg)**] <**Insert value**>.
4. Number of Rack Units per Rack: [**8**] [**12**] [**22**] [**As indicated on Drawings**] <**Insert number**>.
5. Threads: [**10-32**] [**12-24**] [**Universal square**].
6. Wall Attachment: Four mounting holes.
7. Equipment Access: Integral swing.

F. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

## 2.4 23-INCH EQUIPMENT RACKS

A. Description: [**Two-**] [**and**] [**four-**] post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with 23-inch (584.2-mm) panel mounting.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements:

1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: [**Extruded steel**] [**Extruded aluminum**] [**Sheet steel**] [**Sheet aluminum**].
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: [**Black**] <**Insert color**>.

D. Floor-Mounted Racks:

1. Overall Height: [**72 inches (1828.8 mm)**] [**84 inches (2133.6 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Overall Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Rail Depth: [**3 inches (76.2 mm)**] [**6 inches (152.4 mm)**] <**Insert value**>.
4. Two-Post Load Rating: [**200 lb (91 kg)**] [**400 lb (181 kg)**] <**Insert value**>.
5. Four-Post Load Rating: [**1000 lb (454 kg)**] [**2000 lb (907 kg)**] <**Insert value**>.
6. Number of Rack Units: [**38**] [**42**] [**45**] [**52**] [**58**] [**As indicated on Drawings**] <**Insert number**>.

    a. Numbering: [**Every**] [**Every five**] rack units, on interior of rack.

7. Threads: [**10-32**] [**12-24**] [**Universal square**].
8. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug[**, and a power strip**].
9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
10. Top shall have provisions for attaching to cable tray or ceiling.
11. Self-leveling.

E. Wall-Mounted Racks:

1. Height: [**18 inches (457.2 mm)**] [**22 inches (558.8 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Load Rating: [**150 lb (65 kg)**] [**200 lb (91 kg)**] <**Insert value**>.

4. Number of Rack Units: [**8**] [**12**] [**22**] [**As indicated on Drawings**] <**Insert number**>.
5. Threads: [**10-32**] [**12-24**] [**Universal square**].
6. Wall Attachment: Four pre-punched holes.
7. Equipment Access: Integral swing.

F. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

## 2.5 19-INCH EQUIPMENT CABINETS

A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72 inches (450 mm) between rails.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: [**Extruded steel**] [**Extruded aluminum**] [**Sheet steel**] [**Sheet aluminum**].
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: [**Black**] <**Insert color**>.

D. Modular Freestanding Cabinets:

1. Overall Height: [**72 inches (1828.8 mm)**] [**84 inches (2133.6 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Overall Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Load Rating: [**3000 lb (1362 kg)**] <**Insert value**>.
4. Number of Rack Units: [**38**] [**42**] [**45**] [**52**] [**58**] [**As indicated on Drawings**] <**Insert number**>.

    a. Numbering: [**Every**] [**Every five**] rack units, on interior of rack.

5. Threads: [**10-32**] [**12-24**] [**Universal square**].
6. Removable and lockable side and top panels.
7. Hinged and lockable front and rear doors.
8. Adjustable feet for leveling.
9. Screened ventilation openings in roof and rear door.
10. Cable access provisions in roof and base.
11. TGB.

12. [**Rack**] [**Roof**]-mounted, 550-cfm (260-L/s) fan with filter.
13. Power strip.
14. All cabinets keyed alike.

E. Modular Wall Cabinets:

1. Height: [**18 inches (457.2 mm)**] [**22 inches (558.8 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Load Rating: [**150 lb (65 kg)**] [**200 lb (91 kg)**] <**Insert value**>.
4. Number of Rack Units: [**8**] [**12**] [**22**] [**As indicated on Drawings**] <**Insert number**>.
5. Threads: [**10-32**] [**12-24**] [**Universal square**].
6. Lockable front[ **and rear**] doors.
7. Louvered side panels.
8. Cable access provisions top and bottom.
9. Grounding lug.
10. [**Rack**] [**Roof**]-mounted, 250-cfm (118-L/s) fan.
11. Power strip.
12. All cabinets keyed alike.

F. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at top of each relay rack, with a minimum height of two rack units each.

## 2.6 23-INCH EQUIPMENT CABINETS

A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with 23-inch (584.2-mm) equipment mounting.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: [**Extruded steel**] [**Extruded aluminum**] [**Sheet steel**] [**Sheet aluminum**].
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: [**Black**] <**Insert color**>.

D. Modular Freestanding Cabinets:

1. Overall Height: [**72 inches (1828.8 mm)**] [**84 inches (2133.6 mm)**] [**As indicated on Drawings**] <**Insert value**>.

2. Overall Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Load Rating: [**3000 lb (1362 kg)**] <**Insert value**>.
4. Number of Rack Units: [**38**] [**42**] [**45**] [**52**] [**58**] [**As indicated on Drawings**] <**Insert number**>.

    a. Numbering: [**Every**] [**Every five**] rack units, on interior of rack.

5. Threads: [**10-32**] [**12-24**] [**Universal square**].
6. Removable and lockable side and top panels.
7. Hinged and lockable front and rear doors.
8. Adjustable feet for leveling.
9. Screened ventilation openings in roof and rear door.
10. Cable access provisions in roof and base.
11. TGB.
12. [**Rack**] [**Roof**]-mounted, 550-cfm (260-L/s) fan with filter.
13. Power strip.
14. All cabinets keyed alike.

E. Modular Wall Cabinets:

1. Height: [**18 inches (457.2 mm)**] [**22 inches (558.8 mm)**] [**As indicated on Drawings**] <**Insert value**>.
2. Depth: [**23 inches (584.2 mm)**] [**29 inches (736.6 mm)**] <**Insert value**>.
3. Load Rating: [**150 lb (65 kg)**] [**200 lb (91 kg)**] <**Insert value**>.
4. Number of Rack Units: [**8**] [**12**] [**22**] [**As indicated on Drawings**] <**Insert number**>.
5. Threads: [**10-32**] [**12-24**] [**Universal square**].
6. Lockable front[ **and rear**] doors.
7. Louvered side panels.
8. Cable access provisions top and bottom.
9. Grounding lug.
10. [**Rack**] [**Roof**]-mounted, 250-cfm (118-L/s) fan.
11. Power strip.
12. All cabinets keyed alike.

F. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at top of each relay rack, with a minimum height of two rack units each.

## 2.7 OPEN RACK EQUIPMENT RACKS

A. Description: Four-post racks with integral bus bars, equipment support, and dimensions meeting Open Rack Standard v1.2.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements:

1. Frames: Four vertical columns, with perforated top and bottom.
2. Support Shelves: Designed to support equipment 1 OpenU (48 mm) in height.
3. Material:

   a. Frames and Shelves: [**Extruded steel**] [**Extruded aluminum**] [**Sheet steel**] [**Sheet aluminum**].
   b. Bus Bars: Nickel plated copper[**, with silver over-plating**] [**, with gold over-plating**].

4. Finish:

   a. Frames: Manufacturer's standard, baked-polyester powder coat.
   b. Shelves: Hot-dip galvanized according to ASTM A653/A653M.

5. Color: [**Black**] <**Insert color**>.
6. Height: 2100 mm.
7. Width: 600 mm.
8. Depth: 1607 mm.
9. Base shall have a minimum of four [**mounting holes**] [**height-adjustable feet**] for permanent attachment to floor[**, and four casters to allow easy repositioning of rack**].
10. Top shall have provisions for attaching to cable tray or ceiling.
11. Self-leveling.

## 2.8 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting.
3. [**Six**] <**Insert number**> [**15-A, 120-V ac, NEMA WD 6, Configuration 5-15R**] [**20-A, 120-V ac, NEMA WD 6, Configuration 5-20R**] receptacles.
4. LED indicator lights for power and protection status.
5. LED indicator lights for reverse polarity and open outlet ground.
6. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
7. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
8. [**Close-coupled, direct plug-in**] [**Cord connected with 15-foot (4.5-m)**] line cord.
9. Rocker-type on-off switch, illuminated when in on position.
10. Peak Single-Impulse Surge Current Rating: [**33**] [**26**] [**13**] kA per phase.
11. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than [**330 V**] <**Insert value**>.

2.9 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Rack and Cabinet TGBs: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-B. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted TGB: Terminal block, with stainless-steel or copper-plated hardware for attachment to cabinet.
2. Rack-Mounted Horizontal TGB: Designed for mounting in 19- or 23-inch (482.6- or 584.2-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical TGB: 72 or 36 inches (1828.8 or 914.4 mm) long, with stainless-steel or copper-plated hardware for attachment to rack.

2.10 LABELING

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout of communications equipment spaces.

C. Comply with BICSI ITSIMM for installation of communications equipment spaces.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Coordinate layout and installation of communications equipment in racks and room. Coordinate service entrance configuration with service provider.

1. Meet jointly with system providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.

3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment spaces to accommodate and optimize configuration and space requirements of telecommunications equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

## 3.2 GROUNDING

A. Comply with NECA/BICSI 607.

B. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" Ch.

C. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches (50 mm) of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground. Connect rack TGB to near TGB or the TMGB.

1. Bond the shield of shielded cable to patch panel, and bond patch panel to TGB or TMGB.

## 3.3 IDENTIFICATION

A. Coordinate system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Section 270553 "Identification for Electrical Systems."

B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA-606-B for [**Class 2**] [**Class 3**] [**Class 4**] level of administration[**, including optional identification requirements of this standard**].

D. Labels shall be machine printed. Type shall be [**1/8 inch (3 mm)**] [**3/16 inch (5 mm)**] [**1/4 inch (6 mm)**] in height.

END OF SECTION 271116

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# SECTION 271313 - COMMUNICATIONS COPPER BACKBONE CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. High-count Category 3 twisted pair cable.
2. High-count Category 5e twisted pair cable.
3. High-count Category 6 twisted pair cable.
4. Category 6 twisted pair cable.
5. Category 6a twisted pair cable.
6. Category 7 twisted pair cable.
7. Twisted pair cable hardware, including plugs, jacks, patch panels, and cross-connects.
8. Grounding provisions for twisted pair cable.
9. Cabling identification.
10. Source quality control requirements for twisted pair cable.

B. Related Requirements:

1. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for data cabling associated with system panels and devices.

### 1.3 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

B. EMI: Electromagnetic interference.

C. F/FTP: Overall foil screened cable with foil screened twisted pair.

D. FTP: Shielded twisted pair.

E. F/UTP: Overall foil screened cable with unscreened twisted pair.

F. IDC: Insulation displacement connector.

G. Jack: Also commonly called an "outlet," it is the fixed, female connector.

H. LAN: Local area network.

I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

J. RCDD: Registered Communications Distribution Designer.

K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

L. S/FTP: Overall braid screened cable with foil screened twisted pair.

M. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

N. S/UTP: Overall braid screened cable with unscreened twisted pairs.

O. UTP: Unscreened (unshielded) twisted pair.

## 1.4 COPPER BACKBONE CABLING DESCRIPTION

A. Copper backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration Drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system
    e. Cross-connects.
    f. Patch panels.

g. Patch cords.

5. Cross-Connects and Patch Panels: Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Twisted pair cable testing plan.

D. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for lead content.>
2. <Double click to insert sustainable design text for EPDs and HPDs.>

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**RCDD,** ] [**Installer,** ] installation supervisor, and field inspector.

B. Source quality-control reports.

C. Product Certificates: For each type of product.

D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Connecting Blocks: [**One**] <**Insert number**> of each type.
2. Patch-Panel Units: [**One**] <**Insert number**> of each type.
3. Plugs: [**Ten**] <**Insert number**> of each type.
4. Jacks: [**Ten**] <**Insert number**> of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings[ **and cabling administration Drawings**][**, cabling administration Drawings, and field testing program development**] by [**an RCDD**] [**a Technician**].
2. Installation Supervision: Installation shall be under the direct supervision of [**Technician**] [**Level 2 Installer**], who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as [**an RCDD**] [**a Technician**] to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

## 1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

## 1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## 1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

## 1.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for [**two**] <**Insert number**> years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [**two**] <**Insert number**> years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide [**30**] <**Insert number**> days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: [**25**] <**Insert value**> or less.
2. Smoke-Developed Index: [**50**] [**450**] <**Insert value**> or less.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

D. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685[ **or Type CMP in listed plenum communications raceway**] [ **or Type CMP in listed cable routing assembly**].
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
3. Communications, Riser Rated: Type CMR complying with UL 1666[ **and ICEA S-103-701**].
4. Communications, Riser Rated: Type CMP or Type CMR in listed plenum or riser communications raceway.
5. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: [**25**] <**Insert value**> or less.
2. Smoke-Developed Index: [**50**] [**450**] <**Insert value**> or less.

C. RoHS compliant.

2.3 HIGH-COUNT CATEGORY 3 TWISTED PAIR CABLE

A. Description: [**25**] [**50**] [**100**] <**Insert number**>-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 3 cable at frequencies up to 16MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products>**.**

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 3 cables.

D. Conductors: 100-ohm, 24 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded balanced twisted pairs (UTP)**] [**Shielded balanced twisted pairs (FTP)**] [**Screened balanced twisted pairs (F/UTP)**] [**Screened and shielded balanced twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] [**Orange**] [**Pink**] [**Green**] [**Red**] [**Black**] [**Brown**] [**Beige**] [**Mauve**] <**Insert color**> thermoplastic.

2.4 HIGH-COUNT CATEGORY 5e TWISTED PAIR CABLE

A. Description: [**25**] [**50**] <**Insert number**>-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products>**.**

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

D. Conductors: 100-ohm, 24 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded balanced twisted pairs (UTP)**] [**Shielded balanced twisted pairs (FTP)**] [**Screened balanced twisted pairs (F/UTP)**] [**Screened and shielded balanced twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] <**Insert color**> thermoplastic.

2.5 HIGH-COUNT CATEGORY 6 TWISTED PAIR CABLE

A. Description: [**24**] <**Insert number**>-pair, balanced-twisted pair cable,[ **with internal spline,**] certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products>**.**

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded balanced twisted pairs (UTP)**] [**Shielded balanced twisted pairs (FTP)**] [**Screened balanced twisted pairs (F/UTP)**] [**Screened and shielded balanced twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

## 2.6 CATEGORY 6 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable,[ **with internal spline,**] certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products>**.**

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded balanced twisted pairs (UTP)**] [**Shielded balanced twisted pairs (FTP)**] [**Screened balanced twisted pairs (F/UTP)**] [**Screened and shielded balanced twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

## 2.7 CATEGORY 6a TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable,[ **with internal spline,**] certified to meet transmission characteristics of Category 6a cable at frequencies up to 500MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products>**.**

C. Standard: Comply with TIA-568-C.2 for Category 6a cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded balanced twisted pairs (UTP)**] [**Shielded balanced twisted pairs (FTP)**] [**Screened balanced twisted pairs (F/UTP)**] [**Screened and shielded balanced twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

## 2.8 CATEGORY 7 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 7 cable at frequencies up to 600MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standard: Comply with ISO 11801, Category F.

D. Conductors: 100-ohm, 22 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: Overall [**foil shield with foil shielded balanced twisted pairs (F/FTP)**] [**braided shield with foil shielded balanced twisted pairs (S/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

## 2.9 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Cable Connecting Hardware:

1. Twisted pair cable hardware shall meet the performance requirements of [**Category 5e**] [**Category 6**] [**Category 6a**] [**Category 7**].
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.
4. Source Limitations: [**Obtain twisted pair cable hardware from single source from single manufacturer**] [**Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source**].

D. Connecting Blocks: [**110-style IDC for Category 5e**] [**110-style IDC for Category 6**] [**66-style IDC for Category 5e**]. Provide blocks for the number of cables terminated on the block, plus [**25**] <**Insert number**> percent spare, integral with connector bodies, including plugs and jacks where indicated.

E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: [**One**] <**Insert number**> for each conductor in assigned cables.

F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. Replaceable connectors.
d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
3. Number of Jacks per Field: One for each four-pair [**twisted pair cable indicated**] [**conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria**].

G. Plugs and Plug Assemblies:

1. Male; eight position (8P8C); color-coded modular telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.
3. Marked to indicate transmission performance.

H. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.

I. Patch Cords: Factory-made, four-pair cables in [**36-inch (900-mm)**] [**48-inch (1200-mm)**] <**Insert length**>lengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

J. Faceplates:

1. [**Two**][**Four**] [**Six**] port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. [**Eight**] [**Ten**] [**Twelve**] port, vertical double gang faceplates designed to mount to double gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: [**Stainless steel**] [**Brass**] <**Insert description**>, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work-area cords.

    a. Flush-mount jacks, positioning the cord at a 45-degree angle.

K. Legend:

1. Factory labeled by silk-screening or engraving [**for**] [**stainless steel**] [**brass**] <**Insert description**> [**faceplates**].
2. Machine printed, in the field, using adhesive-tape label.
3. Snap-in, clear-label covers and machine-printed paper inserts.

## 2.10 CABLING IDENTIFICATION

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## 2.11 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

## 2.12 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568-C.1.

C. Factory test cables according to TIA-568-C.2.

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

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters[ **and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install cables parallel with or at right angles to sides and back of enclosure.

3.3 INSTALLATION OF PATHWAYS

A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."

B. Comply with Section 270528 "Pathways for Communications Systems."

C. Comply with Section 270529 "Hangers and Supports for Communications Systems."

D. Comply with Section 270536 "Cable Trays for Communications Systems."

E. Drawings indicate general arrangement of pathways and fittings.

3.4 INSTALLATION OF COPPER BACKBONE CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.

2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM)," Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section Use lacing bars and distribution spools.
9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
11. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
12. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [**60 inches (1524 mm)**] <**Insert dimension**> apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [**6 feet (1800 mm)**] <**Insert size**> long not less than [**12 inches (300 mm)**] <**Insert size**> in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

## 3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

## 3.6 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

## 3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: [**1**] [**2**] [**3**] [**4**].
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for [**Class 2**] [**Class 3**] [**Class 4**] level of administration[**, including optional identification requirements of this standard**].

C. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling" for cable and asset management software.

D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, [**backbone pathways and cables,**] [**entrance pathways and cables,**] terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

## 3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform tests and inspections[ **with the assistance of a factory-authorized service representative**].

E. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications

Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

G. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

END OF SECTION 271313

# SECTION 271323 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. 9/125 micrometer single-mode, indoor-outdoor optical fiber cable (OS1).
6. 9/125 micrometer single-mode, indoor-outdoor optical fiber cable (OS2).
7. 9/125 micrometer single-mode, inside plant optical fiber cable (OS1).
8. 9/125 micrometer single-mode, inside plant optical fiber cable (OS2).
9. 9/125 micrometer single-mode, outside plant optical fiber cable (OS1).
10. 9/125 micrometer single-mode, outside plant optical fiber cable (OS2).
11. Optical fiber cable connecting hardware, patch panels, and cross-connects.
12. Cabling identification products.

### 1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. RCDD: Registered Communications Distribution Designer.

### 1.4 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system.
    e. Cross-connects.
    f. Patch panels.
    g. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Optical fiber cable testing plan.

D. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for lead content.>
2. <Double click to insert sustainable design text for environmental product declarations.>

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**RCDD,** ] [**Installer,** ]installation supervisor, and field inspector.

B. Source quality-control reports.

C. Product Certificates: For each type of product.

D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Patch-Panel Units: [**One**] <**Insert number**> of each type.
2. Plugs: [**Ten**] <**Insert number**> of each type.
3. Jacks: [**Ten**] <**Insert number**> of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings[ **and Cabling Administration Drawings**][**, Cabling Administration Drawings, and field testing program development**] by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of [**Technician**] [**Level 2 Installer**], who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an [**RCDD**] [**Technician**].

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use [**optical fiber flashlight**] [**or**] [**optical loss test set**] <**Insert test instrument**>.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining

ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for [**two**] <**Insert number**> years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [**two**] <**Insert number**> years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide [**30**] <**Insert number**> days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: [**25**] <**Insert value**> or less.
2. Smoke-Developed Index: [**50**] [**450**] <**Insert value**> or less.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

D. Grounding: Comply with TIA-607-B.

2.2 62.5/125-MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM1)

A. Description: Multimode, 62.5/125-micrometer, [**4**] [**6**] [**8**] [**12**] [**24**] [**48**] <**Insert number**>-fiber, [**nonconductive,** ] [**conductive** ]tight buffer, optical fiber cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA for detailed specifications.

D. Conductive cable shall be [**steel**] [**aluminum**] armored type.

E. Maximum Attenuation: [**3.50**] <**Insert number**> dB/km at 850 nm; [**1.5**] <**Insert number**> dB/km at 1300 nm.

F. Minimum Overfilled Modal Bandwidth-Length Product: 200 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

G. Jacket:

1. Jacket Color: [**Orange**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR[**; or Type OFCP**]; complying with UL 1666[ **and ICEA S-103-701**].
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.3 50/125 MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM2)

A. Description: Multimode, 50/125-micrometer, [**4**] [**6**] [**8**] [**12**] [**24**] [**48**] <**Insert number**>-fiber, [**nonconductive,** ] [**conductive** ]tight buffer, optical fiber cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAB for detailed specifications.

D. Conductive cable shall be [**steel**] [**aluminum**] armored type.

E. Maximum Attenuation: [**3.50**] <**Insert number**> dB/km at 850 nm; [**1.5**] <**Insert number**> dB/km at 1300 nm.

F. Minimum Overfilled Modal Bandwidth-length Product: 500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

G. Jacket:

1. Jacket Color: [**Orange**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP[ **or Type OFNP**], complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

11. Riser Rated, Conductive: Type OFCR[**; or Type OFCP**]; complying with UL 1666[ **and ICEA S-103-701**].
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

## 2.4 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM3)

A. Description: Multimode, 50/125-micrometer, [**4**] [**6**] [**8**] [**12**] [**24**] [**48**] <**Insert number**>-fiber, [**nonconductive,** ] [**conductive** ]tight buffer, optical fiber cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAC for detailed specifications.

D. Conductive cable shall be [**steel**] [**aluminum**] armored type.

E. Maximum Attenuation: [**3.50**] <**Insert number**> dB/km at 850 nm; [**1.5**] <**Insert number**> dB/km at 1300 nm.

F. Minimum Overfilled Modal Bandwidth-length Product: 1500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

G. Minimum Effective Modal Bandwidth-length Product: 2000 MHz-km at 850 nm.

H. Jacket:

1. Jacket Color: [**Aqua**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

I. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.

6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP[ **or Type OFNP**], complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR[ **or Type OFCP**]; complying with UL 1666[ **and ICEA S-103-701**].
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

## 2.5 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM4)

A. Description: Multimode, 50/125-micrometer, [**4**] [**6**] [**8**] [**12**] [**24**] [**48**] <**Insert number**>-fiber, [**nonconductive,** ] [**conductive** ]tight buffer, optical fiber cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAD for detailed specifications.

D. Conductive cable shall be [**steel**] [**aluminum**] armored type.

E. Maximum Attenuation: [**3.50**] <**Insert number**> dB/km at 850 nm; [**1.5**] <**Insert number**> dB/km at 1300 nm.

F. Minimum Overfilled Modal Bandwidth-length Product: 3500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

G. Minimum Effective Modal Bandwidth-length Product: 4700 MHz-km at 850 nm.

H. Jacket:

1. Jacket Color: [**Aqua**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

I. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR[ **or Type OFCP**]; complying with UL 1666[ **and ICEA S-103-701**].
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

## 2.6 9/125 MICROMETER SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS1)

A. Description: Single mode, 9/125-micrometer, [**6**] [**8**] [**12**] fibers, single loose tube, [**armored**] optical fiber cable.

B. Description: Single mode, 9/125-micrometer, [**24**] [**36**] [**48**] [**72**] [**96**] [**144**] fibers, stranded loose tube, [**armored**] optical fiber cable.

C. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Standards:

1. Comply with TIA-492CAAA for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

E. Armored cable shall be [**steel**] [**aluminum**] armored type.

F. Maximum Attenuation: [**0.5**] <**Insert number**> dB/km at 1310 nm; [**0.5**] <**Insert number**> dB/km at 1550 nm.

G. Jacket:

1. Jacket Color: [**Yellow**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
9. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Armored (Conductive): Type OFCR[ **or Type OFCP**]; complying with UL 1666[ **and ICEA S-103-701**].
12. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

## 2.7 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, [**6**] [**8**] [**12**] fibers, single loose tube, [**unarmored**] [**armored**] optical fiber cable.

B. Description: Single mode, 9/125-micrometer, [**24**] [**36**] [**48**] [**72**] [**96**] [**144**] fibers, stranded loose tube, [**armored**] optical fiber cable.

C. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Standards:

1. Comply with TIA-492CAAB for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.

3. Comply with ICEA S-104-696 for mechanical properties.

E. Armored cable shall be [**steel**] [**aluminum**] armored type.

F. Maximum Attenuation: [**0.5**] <**Insert number**> dB/km at 1310 nm; [**0.5**] <**Insert number**> dB/km at 1550 nm.

G. Jacket:

1. Jacket Color: [**Yellow**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
9. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Armored (Conductive): Type OFCR[ **or Type OFCP**]; complying with UL 1666[ **and ICEA S-103-701**].
12. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

## 2.8 9/125 MICROMETER, SINGLE-MODE, INSIDE PLANT OPTICAL FIBER CABLE (OS1)

A. Description: Single mode, 9/125-micrometer, [**6**] [**8**] [**12**] [**24**] [**36**] [**48**] [**72**] [**96**] [**144**] fibers, tight buffered, optical fiber cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standards:

1. Comply with TIA-492CAAA for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-83-596 for mechanical properties.

D. Conductive cable shall be [**steel**] [**aluminum**] armored type.

E. Maximum Attenuation: [**1.0**] <**Insert number**> dB/km at 1310 nm; [**1.0**] <**Insert number**> dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: [**Yellow**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

## 2.9 9/125 MICROMETER SINGLE-MODE, INSIDE PLANT OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, [**6**] [**8**] [**12**] fibers, single loose tube, optical fiber cable.

B. Description: Single mode, 9/125-micrometer, [**24**] [**36**] [**48**] [**72**] [**96**] [**144**] fibers, stranded loose tube, optical fiber cable.

C. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Standards:

1. Comply with TIA-492CAAB for detailed specifications.

2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-83-596 for mechanical properties.

E. Maximum Attenuation: [**0.5**] <**Insert number**> dB/km at 1310 nm; [**0.5**] <**Insert number**> dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: [**Yellow**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: [**Type OFNR**] [**or**] [**Type OFNP**], complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

## 2.10 9/125 MICROMETER SINGLE-MODE, OUTSIDE PLANT OPTICAL FIBER CABLE (OS1)

A. Description: Single mode, 9/125-micrometer, [**6**] [**8**] [**12**] [**24**] [**36**] [**48**] [**72**] [**96**] [**144**] fibers, tight buffered, optical fiber cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standards:

1. Comply with TIA-492CAAA for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-87-640 for mechanical properties.

D. Maximum Attenuation: [**0.5**] <**Insert number**> dB/km at 1310 nm; [**0.5**] <**Insert number**> dB/km at 1550 nm.

E. Jacket:

1. Jacket Color: [**Black**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.

3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

## 2.11 9/125 MICROMETER SINGLE-MODE, OUTSIDE PLANT OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, [**6**] [**8**] [**12**] fibers, single loose tube, optical fiber cable.

B. Description: Single mode, 9/125-micrometer, [**24**] [**36**] [**48**] [**72**] [**96**] [**144**] fibers, stranded loose tube, optical fiber cable.

C. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Standards:

1. Comply with TIA-492CAAB for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-87-640 for mechanical properties.

E. Maximum Attenuation: [**0.5**] <**Insert number**> dB/km at 1310 nm; [**0.5**] <**Insert number**> dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: [**Black**] <**Insert color**>.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

## 2.12 OPTICAL FIBER CABLE HARDWARE

A. <Double click here to find, evaluate, and insert list of manufacturers and products>**.**

B. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

C. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: [**One**] <**Insert number**> for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

D. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.

E. Connector Type: [**Type SC complying with TIA-604-3-B,**] [**Type ST complying with TIA-604-2-B,**] [**Type LC complying with TIA-604-10-B,**] [**Type MT-RJ complying with TIA-604-12,**] [**Type MPO complying with TIA-604-5-D,**] <**Insert type**> connectors.

F. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than [**0.25**] [**0.75**] <**Insert number**> dB.
3. Marked to indicate transmission performance.

G. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than [**0.25**] [**0.75**] <**Insert number**> dB.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

## 2.13 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

## 2.14 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## 2.15 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.

C. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

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

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[ **and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.

B. General Requirements for Optical Fiber Cabling Installation:

1. Comply with TIA-568-C.1 and TIA-568-C.3.
2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, provide a 10-foot- (3-m-) long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [**6 feet (1800 mm)**] <**Insert size**> long not less than [**12 inches (300 mm)**] <**Insert size**> in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

## 3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

## 3.5 GROUNDING

A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

## 3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: [**Class 1**] [**Class 2**] [**Class 3**] [**Class 4**].
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for [**Class 2**] [**Class 3**] [**Class 4**] level of administration[ **including optional identification requirements of this standard**].

C. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for cable and asset management software.

D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, [**backbone pathways and cables,**] [**entrance pathways and cables,**] terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform tests and inspections[ **with the assistance of a factory-authorized service representative**].

E. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

G. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

END OF SECTION 271323

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# SECTION 271333 - COMMUNICATIONS COAXIAL BACKBONE CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Communications coaxial cable.
2. CATV coaxial cable.
3. Coaxial cable hardware.
4. Grounding.
5. Identification products.

### 1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

### 1.4 COAXIAL BACKBONE CABLING DESCRIPTION

A. Coaxial cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Nominal OD.
2. Minimum bending radius.
3. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.

C. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for environmental product declarations.>
2. Samples: For telecommunications jacks and plugs, [**in specified finish, one for each type and configuration**] [**and faceplates for color selection and evaluation of technical features**].

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**RCDD,** ] [**Installer,** ]installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.7 CLOSEOUT SUBMITTALS

A. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or online.
3. Device address list.
4. Printout of software application and graphic screens.

B. Maintenance Data: For coaxial cable, splices, and connectors to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Connecting Blocks: [**One**] <**Insert number**> of each type.
2. Jacks: [**Ten**] <**Insert number**> of each type.
3. Patch-Panel Units: [**One**] <**Insert number**> of each type.
4. Plugs: [**Ten**] <**Insert number**> of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings[ **and Cabling Administration Drawings**][**, Cabling Administration Drawings, and field testing program development**] by [**an RCDD**] [**a Technician**].
2. Installation Supervision: Installation shall be under the direct supervision of [**Technician**] [**Level 2 Installer**], who shall be present at all times when Work of this Section is performed at Project site.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each coaxial cable [**on the reel**] for continuity.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard, and the requirements of TIA-568-C.4.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Communications Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685[ **or Type CMP in listed plenum communications raceway**] [ **or Type CMP in listed cable routing assembly**].
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
3. Communications, Riser Rated: Type CMR complying with UL 1666[ **and ICEA S-103-701**].
4. Communications, Riser Rated: Type CMP complying with UL 1685, or Type CMR complying with UL 1666[ **and ICEA S-103-701**] in listed plenum or riser communications raceway.
5. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. CATV Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. CATV Plenum Rated: Type CATVP [**installed in riser raceways or cable routing assemblies**], complying with NFPA 262.
2. CATV Riser Rated: Type CATVR complying with UL 1666[**; or CATVP complying with NFPA 262**] [**installed in riser raceways or cable routing assemblies**].
3. CATV Cable: Type CATV[**, or CATVP or CATVR**] [**installed in general purpose, riser, or plenum communications raceways or cable routing assemblies**] in fireproof riser shafts with firestops at each penetration.

2.3 COMMUNICATIONS COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for broadband data transmission.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 13, and with NFPA 70, "Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits" and "Communications Circuits" articles. Types are as follows:

1. RG-6/U: UL Type [**CMR**] [ **and**] [**CL2R**].

    a. No. [**16**] [**18**] <**Insert size**> AWG, solid, copper-covered steel conductor.
    b. Riser rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with [**black**] [**white**] PVC or PE.
    g. Suitable for indoor installations.

2. RG-6/U: UL Type [**CMP**] [ **and**] [**CL2P**].

    a. No. [**16**] [**18**] <**Insert size**> AWG, solid, copper-covered steel conductor.
    b. Plenum rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with [**black**] [**white**] PVC or PE.
    g. Suitable for indoor installations.

3. RG-11/U: UL Type [**CMP**] [ **and**] [**CL2P**].

    a. No. [**14**] <**Insert size**> AWG, solid, copper-covered steel conductor.
    b. Plenum rated. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with sunlight-resistant, [**black**] [**white**] PVC or PE.

4. RG-59/U: UL Type [**CMR**] [ **and**] [**CL2R**].

    a. No. [**20**] <**Insert size**> AWG, solid copper conductor.
    b. Riser rated.
    c. Gas-injected, foam-PE insulation.
    d. Single shielded with 100 percent aluminum shield and 40 percent aluminum braid.
    e. PVC jacket.

5. RG-59/U: UL Type [**CMP**] [ **and**] [**CL2P**].

    a. No. [**20**] <**Insert size**> AWG, solid copper conductor.
    b. Plenum rated.
    c. Gas-injected, foam-PE insulation.
    d. Single shielded with 100 percent aluminum shield and 40 percent aluminum braid.
    e. PVC jacket.

## 2.4 CATV COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for CATV transmission.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Community Antenna Television and Radio Distribution" Article. Types are as follows:

1. RG-6/U: UL Type CATVR.

    a. No. 18 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    b. Riser rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with [**black**] [**white**] PVC or PE.
    g. Suitable for indoor installations.

2. RG-6/U: UL Type CATVP.

    a. No. 18 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    b. Plenum rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with [**black**] [**white**] PVC or PE.
    g. Suitable for indoor installations.

## 2.5 COAXIAL CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate coaxial cable with a 75-ohm characteristic impedance.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Coaxial-Cable Connectors: Type BNC, 75 ohms.

D. Patch Cords: Factory-made cables in [**36-inch (900-mm)**] [**48-inch (1200-mm)**] <**Insert length**> lengths; terminated with modular Type BNC connector at each end.

E. Faceplates:

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: [**Stainless steel**] [**Brass**] <**Insert description**>, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work area cords.

    a. Flush-mounted jacks, positioning the cord at a 90-degree angle.

4. Legend:

    a. Factory labeled by silk-screening or engraving [**for**] [**stainless steel**] [**brass**] <**Insert description**> [**faceplates**].
    b. Machine printed, in the field, using adhesive-tape label.
    c. Snap-in, clear-label covers and machine-printed paper inserts.

## 2.6 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

## 2.7 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## 2.8 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

## PART 3 - EXECUTION

### 3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

### 3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[ **and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

### 3.3 INSTALLATION OF PATHWAYS

A. Comply with requirements specified in Section 271100 "Communications Equipment Room Fittings." Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.

B. Comply with Section 270528.29 "Hangers and Supports for Communications Systems."

C. Drawings indicate general arrangement of pathways and fittings.

D. Comply with NFPA 70 for pull-box sizing and length of conduit and number of bends between pull points.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits [**3 inches (76 mm)**] <**Insert dimension**> above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

## 3.4 INSTALLATION OF COAXIAL BACKBONE CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
2. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
3. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

2. Suspend coaxial cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [**60 inches (1524 mm)**] <**Insert dimension**> apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [**6 feet (1800 mm)**] <**Insert size**> long not less than [**12 inches (300 mm)**] <**Insert size**> in diameter below each feed point.

E. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 3 inches (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

4. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
5. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

## 3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

## 3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

## 3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: [**Class 1**] [**Class 2**] [**Class 3**] [**Class 4**].
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, [**backbone pathways and cables,**] [**entrance pathways and cables,**] terminal hardware and

positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

## 3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform the following tests and inspections[ **with the assistance of a factory-authorized service representative**].

E. Tests and Inspections:

1. Visually inspect coaxial jacket materials for NRTL certification markings.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test coaxial backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

G. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

END OF SECTION 271333

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# SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Category 3 twisted pair cable.
2. Category 5e twisted pair cable.
3. Category 6 twisted pair cable.
4. Category 6a twisted pair cable.
5. Category 7 twisted pair cable.
6. Twisted pair cable hardware, including plugs and jacks.
7. Multiuser telecommunications outlet assembly.
8. Cable management system.
9. Cabling identification products.
10. Grounding provisions for twisted pair cable.
11. Source quality control requirements for twisted pair cable.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for data cabling associated with system panels and devices.

### 1.3 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

B. EMI: Electromagnetic interference.

C. FTP: Shielded twisted pair.

D. F/FTP: Overall foil screened cable with foil screened twisted pair.

E. F/UTP: Overall foil screened cable with unscreened twisted pair.

F. IDC: Insulation displacement connector.

G. LAN: Local area network.

H. Jack: Also commonly called an "outlet," it is the fixed, female connector.

I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

J. RCDD: Registered Communications Distribution Designer.

K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

M. S/FTP: Overall braid screened cable with foil screened twisted pair.

N. S/UTP: Overall braid screened cable with unscreened twisted pairs.

O. UTP: Unscreened (unshielded) twisted pair.

## 1.4 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.

2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration Drawings and printouts.
4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system.
    e. Telecommunications conductor drop locations.
    f. Typical telecommunications details.
    g. Mechanical, electrical, and plumbing systems.

C. Twisted pair cable testing plan.

D. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for lead content.>
2. <Double click to insert sustainable design text for environmental product declarations.>

E. Samples: For telecommunications jacks and plugs, [**in specified finish, one for each type and configuration**] [**and faceplates for color selection and evaluation of technical features**].

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**RCDD,** ] [**Installer,** ] installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

## 1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Connecting Blocks: [**One**] <**Insert number**> of each type.
2. Faceplates: [**One**] <**Insert number**> of each type.
3. Jacks: [**Ten**] <**Insert number**> of each type.
4. Multiuser Telecommunications Outlet Assemblies: [**One**] <**Insert number**> of each type.
5. Patch-Panel Units: [**One**] <**Insert number**> of each type.
6. Plugs: [**Ten**] <**Insert number**> of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings[ **and cabling administration Drawings**][**, cabling administration Drawings, and field testing program development**] by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of [**Technician**] [**Level 2 Installer**], who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for [**two**] <**Insert number**> years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [**two**] <**Insert number**> years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide [**30**] <**Insert number**> days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685[ **or Type CMP in listed plenum communications raceway**] [ **or Type CMP in listed cable routing assembly**].
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
3. Communications, Non-plenum: Type CMR complying with UL 1666[ **and ICEA S-103-701**].
4. Communications, Non-plenum: Type CMP or Type CMR in listed plenum or riser communications raceway.
5. Communications, Non-plenum: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: [**25**] <**Insert value**> or less.
2. Smoke-Developed Index: [**50**] [**450**] <**Insert value**> or less.

C. RoHS compliant.

## 2.3 CATEGORY 3 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 3 cable at frequencies up to 16MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 3 cables.

D. Conductors: 100-ohm, 24 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded twisted pairs (UTP)**] [**Shielded twisted pairs (FTP)**] [**Screened twisted pairs (F/UTP)**] [**Screened and shielded twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] [**Orange**] [**Pink**] [**Green**] [**Red**] [**Black**] [**Brown**] [**Beige**] [**Mauve**] <**Insert color**> thermoplastic.

## 2.4 CATEGORY 5e TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

D. Conductors: 100-ohm, 24 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded twisted pairs (UTP)**] [**Shielded twisted pairs (FTP)**] [**Screened twisted pairs (F/UTP)**] [**Screened and shielded twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] <**Insert color**> thermoplastic.

2.5 CATEGORY 6 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable,[ **with internal spline,**] certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded twisted pairs (UTP)**] [**Shielded twisted pairs (FTP)**] [**Screened twisted pairs (F/UTP)**] [**Screened and shielded twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

2.6 CATEGORY 6a TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable,[ **with internal spline,**] certified to meet transmission characteristics of Category 6a cable at frequencies up to 500MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standard: Comply with TIA-568-C.2 for Category 6a cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: [**Unshielded twisted pairs (UTP)**] [**Shielded twisted pairs (FTP)**] [**Screened twisted pairs (F/UTP)**] [**Screened and shielded twisted pairs (F/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

2.7 CATEGORY 7 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable,[ **with internal spline,**] certified to meet transmission characteristics of Category 7 cable at frequencies up to 600MHz.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Standard: Comply with ISO 11801, Category F.

D. Conductors: 100-ohm, 22 AWG solid copper.

1. <Double click to insert sustainable design text for lead content.>

E. Shielding/Screening: Overall [**foil shield with foil shielded twisted pairs (F/FTP)**] [**braided shield with foil shielded twisted pairs (S/FTP)**].

F. Cable Rating: [**Riser**] [**Plenum**].

G. Jacket: [**White**] [**Gray**] [**Blue**] [**Yellow**] <**Insert color**> thermoplastic.

## 2.8 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of [**Category 5e**] [**Category 6**] [**Category 6a**] [**Category 7**].
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

D. Source Limitations: [**Obtain twisted pair cable hardware from single source from single manufacturer.**] [**Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.**]

E. Connecting Blocks:

1. 110-style IDC for Category 5e.
2. 66-style IDC for Category 5e.
3. 110-style IDC for Category 6.
4. 110-style IDC for Category 6a.
5. Provide blocks for the number of cables terminated on the block, plus [**25**] <**Insert number**> percent spare, integral with connector bodies, including plugs and jacks where indicated.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: [**One**] <**Insert number**> for each conductor in assigned cables.

G. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

    a. Universal T568A and T568B wiring labels.
    b. Labeling areas adjacent to conductors.
    c. Replaceable connectors.
    d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
3. Number of Jacks per Field: One for each four-pair [**cable indicated**] [**conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria**].

H. Patch Cords: Factory-made, four-pair cables in [**36-inch (900-mm)**] [**48-inch (1200-mm)**] <**Insert length**>lengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

I. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.
3. Marked to indicate transmission performance.

J. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.

K. Faceplate:

1. [**Two**][**Four**] [**Six**] port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. [**Eight**] [**Ten**] [**Twelve**] port, vertical double gang faceplates designed to mount to double gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: [**Stainless steel**] [**Brass**] <**Insert description**>, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

L. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

## 2.9 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: MUTOAs shall meet the requirements of "Twisted Pair Cable Hardware" Article.

1. Number of Terminals per Field: [**One**] <**Insert number**> for each conductor in assigned cables.
2. Number of Connectors per Field:

    a. [**One**] <**Insert number**> for each four-pair unshielded or shielded twisted-pair cable indicated.
    b. [**One**] <**Insert number**> for each four-pair unshielded or shielded twisted-pair group of indicated cables, plus [**25**] <**Insert number**> percent spare positions.

3. Mounting: [**Recessed in ceiling**] [**Wall**] [**Desk**] [**Furniture**].
4. NRTL listed as complying with UL 50 and UL 1863.
5. Label shall include maximum length of work area cords, based on TIA-568-C.1.
6. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

## 2.10 CABLE MANAGEMENT SYSTEM

A. Description: Computer-based cable management system, with integrated database[ **and graphic**] capabilities.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Document physical characteristics by recording the network, TIA details, and connections between equipment and cable.

D. Information shall be presented in database view[**, schematic plans, or technical drawings**].

1. [**Microsoft Visio Professional**] [**or**] [**AutoCAD**] drawing software shall be used as drawing and schematic plans software.

E. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

2.11 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.12 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.13 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568-C.1.

C. Factory test twisted pair cables according to TIA-568-C.2.

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

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters[ **and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

## 3.2 INSTALLATION OF PATHWAYS

A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."

B. Comply with Section 270528 "Pathways for Communications Systems."

C. Comply with Section 270529 "Hangers and Supports for Communications Systems."

D. Comply with Section 270536 "Cable Trays for Communications Systems."

E. Drawings indicate general arrangement of pathways and fittings.

## 3.3 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. MUTOA shall not be used as a cross-connect point.
7. Consolidation points may be used only for making a direct connection to equipment outlets:

    a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
    b. Locate consolidation points for twisted-pair cables at least 49 feet (15 m) from communications equipment room.

8. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
9. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
10. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual , Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.

11. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
13. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
14. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [**60 inches (1524 mm)**] <**Insert dimension**> apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [**6 feet (1800 mm)**] <**Insert size**> long not less than [**12 inches (300 mm)**] <**Insert size**> in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

## 3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

## 3.5 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

## 3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: [**Class 1**] [**Class 2**] [**Class 3**] [**Class 4**].
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for [**Class 2**] [**Class 3**] [**Class 4**] level of administration[**, including optional identification requirements of this standard**].

C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

E. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

## 3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform tests and inspections[ **with the assistance of a factory-authorized service representative**].

E. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

G. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

## 3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for [**two**] <**Insert number**> years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [**two**] <**Insert number**> years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide [**30**] <**Insert number**> days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

END OF SECTION 271513

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# SECTION 271533 - COMMUNICATIONS COAXIAL HORIZONTAL CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Communications coaxial cable.
2. CATV coaxial cable.
3. Coaxial cable hardware.
4. Grounding.
5. Identification products.

### 1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. EMI: Electromagnetic interference.

C. IDC: Insulation displacement connector.

D. LAN: Local area network.

E. RCDD: Registered Communications Distribution Designer.

### 1.4 COAXIAL HORIZONTAL CABLING DESCRIPTION

A. Coaxial horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C and the equipment outlet, otherwise known as "Cabling Subsystem 1" in the telecommunications cabling system structure. Cabling system consists of horizontal cables, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Nominal OD.

2. Minimum bending radius.
3. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.

C. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for environmental product declarations.>
2. Samples: For telecommunications jacks and plugs, [**in specified finish, one for each type and configuration**] [**and faceplates for color selection and evaluation of technical features**].

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**RCDD,** ] [**Installer,** ] installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

## 1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For coaxial cable, splices, and connectors to include in maintenance manuals.

## 1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Connecting Blocks: [**One**] <**Insert number**> of each type.
2. Jacks: [**Ten**] <**Insert number**> of each type.
3. Patch-Panel Units: [**One**] <**Insert number**> of each type.
4. Plugs: [**Ten**] <**Insert number**> of each type.

## 1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings[ **and Cabling Administration Drawings**][**, Cabling Administration Drawings, and field testing program development**] by an [**RCDD**] [**Technician**].
2. Installation Supervision: Installation shall be under the direct supervision of [**Technician**] [**Level 2 Installer**], who shall be present at all times when Work of this Section is performed at Project site.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each coaxial cable [**on the reel**] for continuity.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard, and the requirements of TIA-568-C.4.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

## 2.2 GENERAL CABLE CHARACTERISTICS

A. Communications Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685[ **or Type CMP in listed plenum communications raceway**] [ **or Type CMP in listed cable routing assembly**].
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. CATV Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. CATV Plenum Rated: Type CATVP [**installed in riser raceways or cable routing assemblies**], complying with NFPA 262.
2. CATV Cable: Type CATV[**, or CATVP or CATVR**] [**installed in general purpose, riser, or plenum communications raceways or cable routing assemblies**] in fireproof riser shafts with firestops at each penetration.

## 2.3 COMMUNICATIONS COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for broadband data transmission.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 13, and with NFPA 70, "Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits" and "Communications Circuits" articles. Types are as follows:

1. RG-6/U: UL Type [**CMP**] [ **and**] [**CL2P**].

    a. No. [**16**] [**18**] <**Insert size**> AWG, solid, copper-covered steel conductor.
    b. Plenum rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with [**black**] [**white**] PVC or PE.
    g. Suitable for indoor installations.

2. RG-11/U: UL Type [**CMP**] [ **and**] [**CL2P**].

    a. No. [**14**] <**Insert size**> AWG, solid, copper-covered steel conductor.

b. Plenum rated. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg F (minus 40 to plus 30 deg C).
c. Gas-injected, foam-PE insulation.
d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with sunlight-resistant, [**black**] [**white**] PVC or PE.

3. RG-59/U: UL Type [**CMP**] [ **and**] [**CL2P**].

a. No. [**20**] <**Insert size**> AWG, solid copper conductor.
b. Plenum rated.
c. Gas-injected, foam-PE insulation.
d. Single shielded with 100 percent aluminum shield and 40 percent aluminum braid.
e. PVC jacket.

## 2.4 CATV COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for CATV transmission.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Community Antenna Television and Radio Distribution Systems" Article. Types are as follows:

1. RG-6/U: UL Type CATVP.

a. No. 18 AWG, solid, copper-covered steel conductor.
b. Plenum rated.
c. Gas-injected, foam-PE insulation.
d. Shielded with 100 percent aluminum tape and [**40**] [**60**] percent aluminum braid.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with [**black**] [**white**] PVC or PE.
g. Suitable for indoor installations.

## 2.5 COAXIAL CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate coaxial cable with a 75-ohm characteristic impedance.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Coaxial-Cable Connectors: Type BNC, 75 ohms.

D. Jacks and Jack Assemblies: Modular, color-coded, with female Type BNC connectors.

E. Patch Cords: Factory-made cables in [**36-inch (900-mm)**] [**48-inch (1200-mm)**] <**Insert length**>lengths; terminated with a male Type BNC connector at each end.

F. Faceplates:

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: [**Stainless steel**] [**Brass**] <**Insert description**>, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work area cords.

    a. Flush-mounted jacks, positioning the cord at a 90-degree angle from faceplate surface.

4. Legend:

    a. Factory labeled by silk-screening or engraving [**for**] [**stainless steel**] [**brass**] <**Insert description**> [**faceplates**].
    b. Machine printed, in the field, using adhesive-tape label.
    c. Snap-in, clear-label covers and machine-printed paper inserts.

## 2.6 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

## 2.7 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## 2.8 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate horizontal cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters[ **and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used**]. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Comply with Section 271100 "Communications Equipment Room Fittings." Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.

B. Comply with Section 270528.29 "Hangers and Supports for Communications Systems."

C. Drawings indicate general arrangement of pathways and fittings.

D. Comply with NFPA 70 for pull-box sizing and length of conduit and number of bends between pull points.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.

3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits [**3 inches (76 mm)**] <**Insert dimension**> above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

## 3.4 INSTALLATION OF COAXIAL HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
2. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
3. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend coaxial cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [**60 inches (1524 mm)**] <**Insert dimension**> apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [**6 feet (1800 mm)**] <**Insert size**> long not less than [**12 inches (300 mm)**] <**Insert size**> in diameter below each feed point.

E. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 3 inches (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

4. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
5. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

## 3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

## 3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

## 3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: [**Class 1**] [**Class 2**] [**Class 3**] [**Class 4**].
2. Color-code fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, [**horizontal pathways and cables,**] [**entrance pathways and cables,**] terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communications cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

## 3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform the following tests and inspections[ **with the assistance of a factory-authorized service representative**].

E. Tests and Inspections:

1. Visually inspect coaxial jacket materials for NRTL certification markings.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test coaxial horizontal copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

G. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

END OF SECTION 271533

# SECTION 274133 - MASTER ANTENNA TELEVISION SYSTEM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. MATV equipment using **cable television service** as the signal source.
2. MATV headend components.
3. Distribution components.

B. Related Sections:

1. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
2. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
3. Section 271333 "Communications Coaxial Backbone Cabling" for riser-rated coaxial data cabling associated with system panels and devices.
4. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted-pair optical-fiber cables and connectors.
5. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial cables and connectors.
6. Section 282000 "Video Surveillance" for cameras, monitors, computers, and cabling for video surveillance systems.

### 1.3 DEFINITIONS

A. Agile Receiver: A broadband receiver that can be tuned to any desired channel.

B. A/V: Audio/visual.

C. Broadband: For the purposes of this Section, wide bandwidth equipment or systems that can carry signals occupying in the frequency range of 54 to 1002 MHz. A broadband communication system can simultaneously accommodate television, voice, data, and many other services.

D. Carrier: A pure-frequency signal that is modulated to carry information. In the process of modulation, the signal is spread out over a wider band. The carrier frequency is the center frequency on any television channel.

E. CATV: Community antenna television. A communication system that simultaneously distributes several different channels of broadcast programs and other information to customers via a coaxial cable.

F. CCTV: Closed-circuit television.

G. CEA: Consumer Electronics Association.

H. db mV: Decibels relative to 1 mV across 75 ohms. db mV = 20 log 10(V(1)/V(2), where V(1) is the measurement of voltage at a point having identical impedance to V(2) (0.001 V across 75 ohms).

I. Headend: The control center of the MATV system, where incoming signals are amplified, converted, processed, and combined into a common cable along with any locally originated television signals, for transmission to user-interface points. It is also called the "central retransmission facility."

J. I/O: Input/output.

K. MATV: Master antenna television. A small television antenna distribution system usually restricted to one or two buildings.

L. RF: Radio frequency.

M. User Interface: End point of Contractor's responsibility for Work of this Section. User interfaces are the [**terminal blocks to which the end user may connect coaxial cabling**] [**75-ohm terminals on device plates**] <**Define user-interface points**>.

## 1.4 SYSTEM DESCRIPTION

A. System shall consist of [**cable television service**] [**direct broadcast satellite service**] [**an off-air antenna system**] [**CCTV cameras and video recorders**] and a coaxial cable distribution system.

1. Headend equipment shall consist of receiving antennas, satellites, and associated signal distribution amplification and equalization.
2. Distribution of direct broadcast satellite-service signals, which includes coordinating with Owner's selected service provider for installation of its dish-type antennas and processing the signals as needed to provide specified services combined into a single-feed point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.
3. Distribution of cable television service signals, which includes coordinating with Owner's selected service provider for installation of cable to the service point ready for connection into the distribution system. Obtain signal levels and noise and distortion

characteristics from service provider as the point of departure for system layout and final equipment selection.

4. Cable distribution system consisting of coaxial cables, user interfaces, signal taps and splitters, RF amplifiers, signal equalizers, power supplies, and required hardware, complying with EIA/ECA 310-E and CTA-2032-B and resulting in performance parameters specified in this Section. System shall be capable of distributing television channels according to CTA-542-D.

B. Hardware Requirements: Use plug-in, modular, solid-state electronic components. Mount amplifiers and other powered equipment in standard 19-inch (483-mm) cabinet complying with EIA/ECA 310-E.

C. Off-Air Stations: Install antennas for the reception and distribution of selected stations.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For headend and distribution system. Include plans, elevations, sections, details, and attachments to other work.

1. Detail fabrication and installation details for television equipment.
2. Functional Block Diagram: Show single-line interconnections between components for headend and distribution system to user-interface points. Show cable types and sizes.
3. Dimensioned Plan and Elevations of Headend Equipment: Show access and workspace requirements.
4. Wiring Diagrams: For power, signal, and control wiring. Balanced twisted-pair or optical-fiber cable include cross connects, patch panels, and patch cords.

C. Samples: Full size for each outlet device plate in required colors and textures.

D. Design Calculations: Calculate signal attenuation budget and show calculated line and equipment losses for the system based on the functional block diagram, to show that proposed system layout can be expected to perform up to specification. Calculate signal strength from sources to headend input points for each antenna, satellite dish, and CATV grouping. Allowable losses between components and user interface shall be used to determine size and type of coaxial cable.

## 1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Include dimensioned plan and elevation views of components and enclosures. Show access and workspace requirements.

B. Equipment List: Include each piece of equipment and include model number, manufacturer, serial number, location, and date of original installation. Insert testing record of each piece of adjustable equipment, listing name of person testing, date of test, and description of as-left set points.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

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

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Provide no fewer than one of each item listed below. Deliver extra materials to Owner.

1. Fuses: One for every [**10**] <**Insert number**> of each type and rating.
2. Splitters: One for every [**10**] <**Insert number**> installed.
3. MATV Distribution Power Amplifiers: One for every [**10**] <**Insert number**>of each type installed.
4. MATV Signal Traps: [**One**] <**Insert number**> for every [**10**] <**Insert number**> of each type used.
5. MATV Attenuators: [**One**] <**Insert number**> for every [**10**] <**Insert number**> of each type used.
6. Cable: 100 feet (30 m) of each type used.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: System components shall be equipped and rated for the environments in which they are installed.

B. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Interior, Controlled Environment: System components, except central-station control unit, installed in [**air-conditioned**] [**temperature-controlled**] interior environments shall be rated for continuous operation in ambient conditions of [**36 to 122 deg F (2 to 50 deg C)**] <**Insert temperature range**> dry bulb and 20 to 90 percent relative humidity, noncondensing.
2. Interior, Uncontrolled Environment: System components installed in non-[**air-conditioned**] [**temperature-controlled**] interior environments shall be rated for continuous operation in ambient conditions of [**0 to 122 deg F (minus 18 to plus 50 deg C)**] <**Insert temperature range**> dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of [**minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)**] <**Insert temperature range**> dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to

rain as specified in NEMA 250, winds up to [**85 mph (137 km/h)**] <**Insert wind speed**> [**and snow cover up to 24 inches (610 mm) thick**].

1.10 COORDINATION

A. Coordinate size and location of raceway system and provisions for electrical power to equipment specified in this Section.

B. Coordinate Work of this Section with requirements of [**cable television service**] [**direct broadcast satellite service**] [**an off-air antenna system**] [**CCTV cameras and video recorders**] service provider.

C. Coordinate sizes and locations of concrete bases with actual equipment provided.

D. Coordinate installation of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. System shall consist of [**cable television service**] [**direct broadcast satellite service**] [**an off-air antenna system**] [**CCTV cameras and video recorders**] and a coaxial cable distribution system.

1. Headend equipment shall consist of receiving antennas, satellites, and associated signal distribution amplification and equalization.
2. Distribution of direct broadcast satellite-service signals, which includes coordinating with Owner's selected service provider for installation of its dish-type antennas and processing the signals as needed to provide specified services combined into a single-feed point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.
3. Distribution of cable television service signals, which includes coordinating with Owner's selected service provider for installation of cable to the service point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.
4. Cable distribution system consisting of coaxial cables, user interfaces, signal taps and splitters, RF amplifiers, signal equalizers, power supplies, and required hardware, complying with EIA/ECA 310-E and CTA-2032-B and resulting in performance parameters specified in this Section. System shall be capable of distributing television channels according to CTA-542-D.

B. Hardware Requirements: Use plug-in, modular, solid-state electronic components. Mount amplifiers and other powered equipment in standard 19-inch (483-mm) cabinet complying with EIA/ECA 310-E.

C. Off-Air Stations: Install antennas for the reception and distribution of selected stations.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum acceptable performance of distribution system at all user-interface points shall be as follows:

1. RF Video-Carrier Level: Between 3 and 12 db mV.
2. Relative Video-Carrier Level: Within 3 db to adjacent channel.
3. Carrier Level Stability, Short Term: Level shall not change more than 0.5 db during a 60-minute period.
4. Carrier Level Stability, Long Term: Level shall not change more than 2 db during a 24-hour period.
5. Channel Frequency Response: Across any 6-MHz channel in the 54- to 220-MHz frequency range, referenced to video; signal amplitude shall be plus or minus 1 db, maximum.
6. Carrier-to-Noise Ratio: 45 db or more.
7. RF Visual Signal-to-Noise Ratio: 43 db or more.
8. Antenna Combiner Insertion Loss: 40 db maximum.
9. Signal Power Splitter and Isolation Tap Return Loss: 17 db maximum.
10. Cable Connectors Attenuation: Less than 0.1 db.
11. Cross Modulation: Less than minus 50 db.
12. Carrier-to-Echo Ratio: More than 40 db.
13. Composite Triple Beat: Less than minus 53 db.
14. Second Order Beat: Less than minus 60 db.
15. Terminal Isolation from Television to Television: 25 db, minimum.
16. Terminal Isolation between Television and FM: 35 db, minimum.
17. Hum Modulation: 2 percent, maximum.
18. RF FM Carrier Level: 13 to 17 db below video-carrier level.
19. FM Frequency Response: More than in the 88- to 108-MHz frequency range; signal amplitude is plus or minus 0.75 db, maximum.
20. FM Carrier-to-Noise Ratio: More than 24 db.

2.3 SYSTEM REQUIREMENTS

A. Components: Plug-in, modular, heavy-duty, industrial- or commercial-grade units.

B. Equipment: Silicon-based, solid-state, integrated circuit devices.

C. Power Supply Characteristics: Devices shall be within specified parameters for ac supply voltages within the range of 105 to 130 V.

D. Protect signal cables and connected components against transient-voltage surges by suppressors and absorbers designed specifically for that purpose. Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

E. Provide ac-powered equipment with integral surge protection devices complying with UL 1449.

F. RF and Video Impedance Matching: Signal-handling components, including connecting cable, shall have end-to-end impedance-matched signal paths. Match and balance devices used at connections where it is impossible to avoid impedance mismatch or mismatch of balanced circuits to unbalanced circuits.

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

## 2.4 MATV EQUIPMENT

A. Description: Signal-source components, signal-processing and amplifying equipment, distribution components, and interconnecting wiring. System shall receive, amplify, process, and distribute signals to outlets for receiving sets. Equipment shall translate UHF channels to VHF channels before distribution to outlets.

B. Identification of Signal Sources Distributed:

1. <**Insert signal sources and basic service selection**>.

C. MATV System Qualitative and Quantitative Performance Requirements: Reception quality of color-television program transmissions at each system outlet from each service and source shall be equal to or superior than that obtained with performance checks specified in "Field Quality Control" Article, using standard, commercial, cable-ready, multiple A/V input color-television receivers.

## 2.5 OFF-AIR ANTENNAS

A. Antennas shall be tested, marked, and packaged, according to CTA-774-A, CEA-2028-B, and CEA-2032-B. Antennas shall be labeled according to CEA antenna mapping program.

B. Off-Air, Mast-Mounted Antennas: Weatherproof single-channel or broadband type, constructed of high-strength anodized aluminum and rated to survive in a [**100-mph (160-km/h)**] <**Insert speed**> wind, minimum.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Elements: Internally dampened against mechanical vibration that may occur in service.
3. Ends of Crossarms and Elements: Sealed.
4. Mounting and Connecting Hardware: Corrosion proof.
5. Frequency Range: Matched to source frequencies.
6. CEA Reception Patterns: <**Insert reception pattern and number of antennas**>.
7. FM Antenna: Separate from the broadband antenna and the [**omnidirectional**] [**directional**] antenna, with 2-db minimum gain.

C. Antenna-Supporting Structures: Prefabricated, hot-dip galvanized-steel units.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Strength of Structure and Attachments: Adequate to withstand [**100-mph (160-km/h)**] <**Insert speed**> winds while supporting installed antennas.
3. Comply with 47 CFR 17 and TIA 222-G.
4. Comply with FAA AC 70/7460-1L.

## 2.6 MATV HEADEND COMPONENTS

A. Headend Equipment.

1. Components:

   a. Channel mixers.
   b. Processors.
   c. Broadband amplifier.
   d. Single-channel amplifiers.
   e. FM module.
   f. Combining networks.

2. Description: For receiving off-air television and FM signals and outputting the signals to cable distribution system. Equip coaxial down-leads of the off-air antennas with preamplifiers to send signals at strength required by headend. Headend component performance specified in this article is minimum acceptable; better performance may be required to comply with minimum acceptable system performance standard in "Performance Requirements" Article.
3. <Double click here to find, evaluate, and insert list of manufacturers and products.>
4. House units in standard 19-inch (483-mm) electronic equipment cabinet complying with EIA/ECA 310-E.

B. Antenna Combiner: Directional coupler design network, combining up to eight antenna signals into a single output. Frequency response of the device shall be 5 to 400 MHz, and the insertion loss between input ports shall be not less than 40 db.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Down-Lead Preamplifiers: Antenna mast-mounted preamplifier, designed to boost antenna signal and contained in weatherproof housing; single-channel or broadband type. Install power supplies indoors at headend equipment, connected through power inserters to provide power to preamplifiers through the coaxial down-lead cable.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Frequency Response: Plus or minus 0.75 db.
3. Minimum Input: Minus 20 db mV.
4. Return Loss: 14 db.
5. I/O Impedance: 75 ohms.

D. Channel Mixers: Use for nonadjacent channels only.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Insertion Loss (Maximum 54 to 216 MHz): 2.5 db.
3. Return Loss: 14 db.
4. Out-of-Band Rejection: 12 db.
5. I/O Impedance: 75 ohms.

E. Processors: One for each channel to be translated.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Bandwidth: 6 MHz.
3. Return Loss: 16 db, within the 6-MHz bandwidth.
4. Noise: Not more than 10 db at maximum gain.
5. Input Level Range, VHF: Minus 20 to plus 30 db mV.
6. Input Level Range, UHF: Minus 20 to plus 25 db mV.
7. Output Level Range: 50 to 60 db mV.
8. Carrier-to-Noise Ratio: Minus 57 db at plus 10-db mV input.
9. Automatic Gain Control: Plus or minus 1-db output variation for rated input level range variation.
10. Frequency Stability: Plus or minus 10 kHz over the operational temperature range.
11. Spurious Output: 60 db below the video carrier with video-carrier output level at plus 60 db mV and audio-carrier level at plus 45 db mV.
12. Adjacent Channel Rejection: Not less than 60 db.
13. I/O Impedance: 75 ohms.

F. Broadband Amplifier:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Frequency Range: [**54 to 108, 174 to 220**] [**54 to 220**] MHz.
3. Frequency Response: Plus or minus 1.0 db across passband.
4. Maximum Noise: 10 db.
5. Minimum Return Loss: 16 db.
6. I/O Impedance: 75 ohms.

G. Single-Channel Amplifiers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Frequency: 6 MHz for specified channel.
3. Frequency Response: Plus or minus 0.5 db.
4. Maximum Noise: 10 db.
5. Minimum Return Loss: 14 db.
6. Automatic Gain Control: Plus or minus 1-db output variation for rated input level range variation.
7. Skirt Rejection: Minus 26 db at plus or minus 5 MHz from channel center.
8. Sound Trap: Adjustable to 10 Vdb of attenuation of the sound carrier.
9. I/O Impedance: 75 ohms.

H. FM Module: One RF processor module for each station listed.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Frequency Range: Between 88 and 108 MHz.
3. Output Level: 52 db mV.
4. Output Level Control: Plus or minus 10 db.
5. Stability: 0.005 percent, crystal controlled.
6. Sensitivity: 3 mV for 30-db quieting.
7. Input Level: 60 mV, stereo.
8. Image Rejection: 901 db.
9. Passband: 200 kHz.
10. Selectivity: Plus or minus 150 kHz or less, at 30 db down. Plus or minus 250 kHz or less, at 50 db down.

I. Combining Network (Mixer): Combines the off-air television [**FM**] [**CCTV**] [**and**] [**CATV**] signals into a single-broadband output. An output test point, a 75-ohm television jack, a mixer output step attenuator dual-pilot insertion network, and a removable mixer-to-trunk jumper are included.

1. Passband: As required by system performance.
2. Distortion: Not more than plus or minus 0.1 db over any 6-MHz segment.
3. Distortion: Not more than plus or minus 0.5 db over the 54- to 216-MHz frequency range.
4. Nominal Insertion Loss:

    a. 15 db maximum, channel input to single-system output.
    b. 13 db maximum, channel input to mixer output.
    c. 20 db maximum at test point (e.g., loss from trunk output).

5. Isolation between Any Two Inputs: 30 db.
6. I/O Impedance: 70 ohms.

## 2.7 DISTRIBUTION COMPONENTS

A. Signal Power Splitters and Isolation Taps: Metal-enclosed directional couplers with brass connector parts. Where installed in signal circuits used to supply cable-powered amplifiers, power throughput capacity shall exceed load by at least 25 percent.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Return Loss: 17 db.
3. RFI Shielding: 100 db.
4. Isolation: 25 db.
5. I/O Impedance: 75 ohms.

B. Distribution System Amplifiers: Powered by coaxial cable system and equipped with surge protection device and external test points to allow convenient signal monitoring.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Cable System Power Supplies: Plug-in, modular construction, with surge, short-circuit, and overload protection.

D. Signal Traps: Packaged filters tuned to interference frequencies encountered in Project.

E. Attenuators: Passive, of fixed value, and used to balance signal levels.

F. Terminating Resistors: Enclosed units rated 0.5 W and matched for coaxial impedance.

G. Jack: Flush, female-type outlets, designed to mimic power duplex outlet; for mounting in standard outlet box; with metallic parts of anodized brass, beryllium copper, or phosphor bronze. Cable connector mounting shall be semirecessed, so its protrusion is flush with the plane of device plate.[ **Feed-through-type cable connection shall not be used**] [**, except in area housing a single tenant**] [**, except within a single-dwelling unit**].

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Cable Connector: Female, Type F.
3. Wall Plates: Match materials and finish of power outlets in same space.
4. Attenuation: Less than 0.1 db.
5. Voltage Standing-Wave Ratio: Less than 1.15 to 1.

## 2.8 ENCLOSURES

A. Enclosures for Interior, Controlled Environments: NEMA 250, Type 1.

B. Enclosures for Interior, Uncontrolled Environments: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 12**] [**Type 12K**].

C. Enclosures for Exterior Environments: NEMA 250, [**Type 3**] [**Type 3R**] [**Type 3S**] [**Type 4**] [**Type 4X**].

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine roughing-in for antenna to verify actual locations of cable connections before antenna installation.

B. Examine walls, floors, roofs, equipment bases, and roof supports for suitable conditions where television equipment is to be installed.

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

## 3.2 INSTALLATION

A. Install signal line surge suppressors on coaxial cables entering headend equipment space and at antenna-mounted amplifiers. Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

B. Install antenna towers, masts, and mountings on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

## 3.3 ANTENNA AND HEADEND INSTALLATION

A. Mount headend equipment in electronic equipment cabinets recommended by manufacturer. Group related items in methodical sequence.

B. Arrange equipment to facilitate access for maintenance and to preserve headroom and passage space. Parts that require periodic service or maintenance shall be readily accessible. Headend components that require tuning adjustments shall be accessible from the front of equipment cabinets.

C. Align antenna elements to achieve maximum signal level and quality.

D. Antenna-Supporting Structure: Increase antenna height as required to obtain signal strength needed for specified system performance.

1. Attachment to Building: Use 0.375-inch- (10-mm-) minimum expansion anchors for masonry, and place anchors clear of grout or mortar joints.
2. Attachment to Building: Use 0.375-inch- (10-mm-) minimum lag bolts for attachment to wood.
3. Lightning Protection: Comply with requirements in Section 264113 "Lightning Protection for Structures."

E. Antenna Cable Entrance: Use weatherproof entrance fittings, and seal at penetrations of the building envelope.

## 3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

3.5 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections:

1. Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements.
2. Replace malfunctioning or damaged items.
3. Retest until satisfactory performance and conditions are achieved.
4. Prepare television equipment for acceptance and operational testing.
5. Use an agile receiver and signal strength meter or spectrum analyzer for testing.
6. Off-Air, Mast-Mounted Antenna Sources: Connect receiver to the down-lead of a 10-element, single-channel antenna, tuned and oriented to optimize reception for the channel and placed at system antenna's location. Alternatively, connect receiver to a single-channel video amplifier connected to the down-lead of the above single-channel antenna.
7. CATV Sources: Connect receiver to an agile demodulator or CATV set-top converter at CATV service entrance to the facility.
8. Satellite Earth-Station System Sources: Adapt receiver to the output of satellite-television receiver.
9. CCTV Sources: Connect receiver to the output of each CCTV signal source or the distribution amplifier associated with it.
10. Test Schedule: Schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
11. Operational Tests: Perform tests of operational system to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
12. Distribution System Acceptance Tests:

    a. Field-Strength Instrument: Rated for minus 40-db mV measuring sensitivity and a frequency range of 54 to 812 MHz, minimum. Provide documentation of recent calibration against recognized standards.
    b. Signal Level and Picture Quality: Use a field-strength meter or spectrum analyzer, and a standard television receiver to measure signal levels and check picture quality at [**all**] [**25 percent of**] <**Insert number or percentage**> user-interface outlets.

        1) Test the signal strength in db mV at 55[**, 151, 547,**] and 750 MHz.
        2) Minimum acceptable signal level is 0 db mV (1000 mV).
        3) Maximum acceptable signal level over the entire bandwidth is 15 db mV.
        4) Television receiver shall show no evidence of cross-channel intermodulation, ghost images, or beat interference.

13. Signal-to-Noise-Ratio Test: Use a field-strength meter to make a sequence of measurements at the output of the last distribution amplifier or of another agreed-on

location in system. With system operating at normal levels, tune meter to the picture carrier frequency of each of the designated channels in turn, and record the level. With signal removed and input to corresponding headend amplifier terminated at 75 ohms, measure the level of noise at same tuning settings. With meter correction factor added to last readings, differences from first set must not be less than 45 db.

14. Qualitative and Quantitative Performance Tests: Demonstrate reception quality of color-television program transmissions at each user interface from each designated channel and source. Quality shall be equal to or superior than that obtained with performance checks specified below, using a standard, commercial, cable-ready, color-television receiver. Level and quality of signal at each outlet and from each service and source shall comply with the following Specifications when tested according to 47 CFR 76:

    a. RF video-carrier level.
    b. Relative video-carrier level.
    c. Carrier level stability, during 60-minute and 24-hour periods.
    d. Broadband frequency response.
    e. Channel frequency response.
    f. Carrier-to-noise ratio.
    g. RF visual signal-to-noise ratio.
    h. Antenna combiner insertion loss.
    i. Signal power splitter loss.
    j. Cable connector attenuation.
    k. Cross modulation.
    l. Carrier-to-echo ratio.
    m. Composite triple beat.
    n. Second order beat.
    o. Terminal isolation.
    p. Terminal isolation between television and FM.
    q. Hum modulation.
    r. RF FM carrier level.
    s. FM frequency response.
    t. FM carrier-to-noise ratio.

C. Headend and distribution system will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Cap all unused connectors and seal weathertight.

## 3.6 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain MATV equipment.

1. Train Owner's maintenance personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.

2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.
3. Demonstrate programming and tuning of satellite receivers.

END OF SECTION 274133

# SECTION 280500 – COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This section includes general requirements for Division 28 work and is supplemental and in addition to the requirements of Division 1.

B. It is the intention of this Division of the Specifications to describe and provide for the furnishing, installing, testing and placing in satisfactory and fully operational condition all equipment, materials and devices necessary to provide a complete Division 28 system.

C. The Division 28 Security Systems shall be bid to the Detention Equipment Contractor as a complete package. Delineation of responsibilities between the Division 11, 26 and 28 contractors are specified herein.

D. The Division 28 Security Systems Integrator (SSI) shall be responsible for the coordination, furnishing and installation of all Division 28 systems, which shall include the following:

1. 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY & SECURITY
2. 280510 – CABINETS AND ENCLOSURES
3. 281300 – ACCESS CONTROL SYSTEM
4. 282300 – IP VIDEO COMMUNICATION SYSTEM
5. 284619 – SECURITY AUTOMATION SYSTEM
6. 284620 – VIDEO GRAPHIC USER INTERFACE
7. 285123 – IP AUDIO COMMUNICATION SYSTEM

E. The Division 26 contractor shall design, furnish, install and place in satisfactory condition all conduits/raceways, boxes (back boxes and junction boxes), conductors and connections and all other materials required for the Division 28 systems specified in the contract documents to be complete and fully operational upon completion of the project.

F. All cabling provided by the Division 26 contractor shall be in conduit where determined, and continuous between the field device and the head-end equipment location. The Division 26 contractor shall maintain uniform phasing and color-coding throughout system, adhering to the approved Division 28 shop drawings.

G. The SSI shall coordinate with the Division 26 contractor all requirements of the security electronics cable system including PLC/GUI, video surveillance, access control, audio communications, and other miscellaneous systems per NEC, as shown in the project documents.

H. The Division 26 contractor shall set in place all SSI-supplied security equipment cabinets, racks and enclosures. The SSI shall provide documentation detailing the required installation.

I. The Division 26 contractor shall be responsible for the provision and installation/terminations of all required 120VAC power, including UPS circuits, for the security electronics head-end equipment and control station location equipment.

J. The Division 26 contractor shall be responsible for the installation and terminations of all distribution circuits between Division 26-supplied breaker panels and SSI-supplied utility relay interface panels controlling lighting and power circuits.

K. The Division 26 contractor shall be responsible for all cabling/conduit coordination in regard to electric locks, position switches, door hardware and door frames supplied by Division 8 and/or Division 11 contractor(s).

L. The Division 26 contractor shall be responsible for all Division 28 **field device** installation and terminations. The SSI shall be responsible for all **head-end** equipment terminations. The SSI shall be responsible for the installation and terminations of all control station equipment, including GUI PCs, monitors, network client PCs and monitors.

M. The General Contractor shall provide coordination to ensure that control rooms and rooms housing security electronics head end equipment are completed, clean and have conditioned air as early as possible to facilitate completion of control wiring and terminations. Space shall be free of air-borne particles prior to installation of any Security Electronics Equipment. The Architect shall inspect and approve the condition of these rooms prior to the installation of any active equipment.

N. The Division 11 contractor shall furnish and install all security hardware, adjust all door position and lock position switches as necessary to properly indicate to the security electronics system, provide all hardware and frame schedules as necessary to pertinent contractors, and provide all wiring diagrams to the SSI and Division 26 contractors for electric locking devices being interfaced to by the security electronics system.

O. The Owner shall be responsible for providing a high-speed internet connection to the Security Management System for remote diagnostics by the SSI. The Owner shall provide a network connection between their LAN and the video management system. Configuration of the Owner's network switches shall be by the Owner. Inmate Telephone system terminations at the SSI-supplied telephone relay interface panel shall be by the Owner's telephone system contractor.

## 1.3 DEFINITIONS

A. UL: Underwriters Laboratories

B. NEMA: National Electrical Manufacturer's Association

C. NEC: National Electrical Code

D. NFPA: National Fire Protection Association

E. SSI: Security System Integrator

1.4 SUBMITTALS

A. General: Submit the following information to be included in the submittal package.

B. Product Data:
1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Indicate specification section and paragraph for each item.
3. Indicate listing by UL or other approved testing agency.
4. Data sheets showing multiple products or models shall clearly identify the specific product or model being proposed.
5. Submit in a three-ring binder with hardboard covers.

C. Shop Drawings: Submitted shop drawings shall be generated utilizing AutoCAD and shall be drawn to the drawing/detail scale. The Electronic Safety and Security shop drawings shall include, but not be limited to the following:

1. Dimensions, weights, loads, required clearances, method of field assembly, location and size of each field connection.
2. Detailed equipment enclosure drawings showing arrangement of all proposed equipment with required wire-way and receptacles shown.
3. System risers showing all required interconnections for the following subsystems along with any special terminations that may be required for that subsystem:

    a. Overall Electronic Safety and Security System
    b. PLC I/O Network
    c. Ethernet Network
    d. Video Surveillance System
    e. Digital Intercom System
    f. Utility & Misc. Systems

4. Submit power system drawings indicating all fuse ID numbers as well as voltage and size.
5. Submit power loading spreadsheets detailing all AC power circuits and DC power supply circuits. The spreadsheet shall indicate each device's steady state and in rush current requirements.
6. Submit device schedules that reference the shop drawings detailing exact termination locations for each security device in the system. The device schedules shall indicate the name, location, termination point, voltage, and fuse ID for each. The schedules shall be categorized by device type (i.e. doors, intercoms, cameras, proximity readers, etc.).

D. Operation and Maintenance Data: Provide O&M manuals as required below:

E. The O&M manuals shall include the information required to operate and maintain all Division 28 electronic security system equipment. The information provided shall include the following:

1. Operations manual for GUI and Security Management System.
2. As-built shop drawings, including up-to-date device schedules.
3. Wiring diagrams.
4. CD with manufacturer's installation and operations manuals.
5. Complete list of spare parts being provided.
6. The current contact (including service) information for the SSI.
7. Provide two (2) copies of each operating and maintenance manual. Manuals shall be bound in "D-ring" binders with a detailed table of contents.
8. Provide one electronic copy of the O&M manual for inclusion with the O&M manual deliverables on a USB flash drive.

F. Software Deliverables: Provide a software binder that shall incorporate the following files and information;

1. Provide a text file containing all operator and administrator-level passwords for the GUI system, Security Management system, digital intercom system, PLC system and DVMS.
2. PC recovery files, GUI runtime licenses, digital intercom system software, VMS software, PLC software, and monitor drivers.

1.5 QUALITY ASSURANCE

A. Security Systems Integrators

1. Only PRE-QUALIFIED Security System Integrators (SSIs) shall be permitted to bid on the Division 28 Electronic Security Systems.
2. The pre-qualified SSIs shall only be allowed to furnish materials from the manufacturers as specified in the Division 28 specifications.
3. The SSI shall assume sole-source responsibility for the entire electronic security system and shall not subcontract out any programming work associated with the GUI or PLC systems. The SSI shall ensure that all integrated systems are compatible with each other for a complete, fully operational and fully tested system upon completion of the project.
4. The SSI shall furnish and install only new material, unused without any defects.
5. The following pre-qualified Security System Integrators (SSI's) shall be allowed to submit pricing:

**a. Security Automation Systems, Inc. (Indianapolis, IN)**

**b. Accurate Controls, Inc. (Ripon, WI)**

B. All work shall conform to the applicable code provisions of the NEC and NFPA (as adopted and amended by the Local Jurisdiction).

1.6 COORDINATION

A. Coordinate the work of this section to meet the substantial completion date.

B. Coordinate the delivery and location of items with the Construction Manager.

C. Special attention is called to the following items. Coordinate all conflicts prior to installation:

1. Location of millwork, control consoles, counters, desks, doors and frames so that Division 28 material is in proper relation to these items.
2. Scheduling of new equipment for installation.

D. The SSI shall coordinate their security equipment rack space requirements with the Owner in shared spaces.

1.7 DELIVERY, STORAGE, AND HANDLING

A. SSI shall mark or tag each relevant item of equipment (cameras, housings, monitors, etc.) for the project. The SSI shall deliver equipment at the proper time and location for installation. Equipment received, but not installed shall be placed in secured storage. Handling shall be controlled to prevent losses and delays. Upon delivery, the SSI shall inspect equipment for damage. All damaged items shall be removed from the site and replaced.

B. For equipment stored off-site, the SSI shall protect equipment from theft or damage. All items stored for the project shall be clearly labeled as such and shall be available for inspection. Shipping receipts for stored items shall be made available upon request. The SSI shall provide appropriate insurance coverage for stored equipment that shall cover all items against theft or damage.

1.8 WARRANTY

A. The SSI shall warrant all material and workmanship for Division 28 systems for a period of twelve (12) months after substantial completion (see ADJUSTING, section 3.5). The warranty shall cover all material and software provided. The SSI shall provide qualified and/or manufacturer-certified technicians capable of diagnosing and repairing the installed system.

B. The SSI shall repair or replace (at no cost to the Owner) any defective materials or work when given written notice during the warranty period. Warranty service shall be provided to the Owner during normal working hours. When requested by the Owner, after-hours service (including on-site service) shall be provided and the SSI’s applicable labor and travel rates shall apply.

C. The SSI shall provide emergency service during the 12-month warranty period. The SSI shall provide the owner a 4-hour phone response time and a one business-day response time for major system failures. Major system failures shall be considered those failures which result in limited or no functionality of major electronic security system components, such as a PLC failure or a GUI failure.

D. The warranty shall exclude acts of vandalism, abuse, neglect, Owner misuse, failure of the Owner to provide continuous environmental conditions for which the installed equipment is rated for, and all other acts beyond the control of the SSI (i.e. – weather damage, floods, fire, lightning, and similar acts).

1.9 EXTRA MATERIALS

A. The SSI shall reference each specific section in Division 28 for extra materials required. Extra materials shall match products installed and shall be packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect the conditions under which Work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances.

C. Comply with manufacturer's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

D. Precautions shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

3.2 INSTALLATION

A. Provide complete electronic security system as specified herein.

B. All system equipment to be contained within equipment racks or cabinets. If more or larger equipment racks or cabinets are required than exist or are indicated on the drawings, allow for such additional equipment racks and cabinets in contract price.

C. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

D. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

E. All cable within equipment racks, cabinets, or on backboards, to be neatly bundled and secured.

F. Wires shall not be nicked, have strands removed, or have frayed strands when removing insulation or terminating.

G. Factory manufactured interface cables to be provided for each field interface board. Terminal blocks to be provided in cabinet or on backboard for factory cable interface to field wiring.

H. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

I. Seal-tite flexible conduits, NEMA-rated weatherproof junction boxes connectors shall be utilized for exterior camera locations.

## 3.3 CONNECTIONS

A. For equipment furnished under this Division of the specifications, provide all Division 28 connections necessary so that the equipment is fully operational upon completion of the project.

B. Ground equipment according to manufacturer’s recommendations.

## 3.4 FIELD QUALITY CONTROL

A. Verify that the electronic security system work is installed according to the Contract Documents. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents. Perform additional inspections to determine compliance of replaced or additional work.

B. Manufacturer's Field Service: The SSI shall provide a qualified technician and/or factory-authorized service representative to inspect, test, and adjust security electronic security system components and equipment installation, including connections, and to assist in field testing.

C. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After the security electronic system has been energized, perform an operational test of the system to verify compliance with the Contract Documents.
2. When test results indicate that electronic security work does not comply with the Contract Documents, the SSI shall diagnose and correct the deficiencies.
3. Retesting: At the SSI’s expense, test and adjust electronic security system head-end equipment and field devices. Replace damaged and malfunctioning equipment.

D. Remove and replace malfunctioning equipment and retest as specified above.

## 3.5 ADJUSTING/SCHEDULED MAINTENANCE

A. SSI shall provide initial electronic security system configuration and adjustments. All field devices and head-end equipment shall be adjusted for optimum performance.

B. Occupancy Adjustments: The SSI shall provide two (2) scheduled, on-site preventative maintenance/adjustment visits during the warranty period. During these visits, the SSI shall make any necessary adjustments to the electronic security system and replace/repair any defective equipment and/or workmanship found. The duration of each visit shall be a minimum of 4 hours. Each visit shall be documented in a maintenance log and shall be presented to the Owner.

## 3.6 SYSTEM TESTING

A. Prior to the shipment of the PLC and GUI control systems to the project site, the SSI shall provide a full system test of all security electronic control system equipment. All control system hardware head-end equipment, including all PLC input and output points, shall be tested with the GUI software and Security Management system. The SSI shall make all necessary software modifications/corrections based on the results of the testing. The control systems shall be re-tested after the software modifications/corrections have been made.

B. At a minimum of 30 days prior to the shipment of the control system equipment to the project site, the SSI shall notify the Owner that the control system equipment is tested and ready to be demonstrated. This demonstration shall be conducted at the site of the SSI. During the demonstration, the SSI shall coordinate with the Owner to make any programming/configuration changes to the system. These changes may include minor changes to the layout and text on the GUI screens, based on the operational requirements of the Owner.

## 3.7 DEMONSTRATION

A. Provide qualified and/or manufacturer-certified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the electronic security system. Refer to Division 01 Section “Demonstration and Training”.

B. Provide demonstration and instruction sessions to familiarize Owner’s operation and maintenance personnel with systems and their operation and maintenance.

C. Establish agendas for demonstration and instruction sessions in conjunction with the Architect and Owner. Coordinate scheduling of sessions with the Architect and Owner.

D. Provide two 8-hour seminars to demonstrate operation of the systems.

E. Provide two 8-hour technical seminars to demonstrate configuration, troubleshooting, repair and maintenance of the system.

F. Training shall be video recorded.

END OF SECTION 280500

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# SECTION 280510 – CABINETS AND ENCLOSURES FOR ELECTRONIC SAFETY AND SECURITY

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 and Division 28 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the requirements for Cabinets and Enclosures for the Electronic Safety and Security system. The cabinets and enclosures shall contain all Electronic Security System head-end equipment.

B. The Cabinets and Enclosures for the Electronic Safety and Security system shall include the following main components:

1. Security Equipment Enclosures:

    a. Free-Standing Security Equipment Enclosures.

    b. Wall-Mount Racks.

    c. Wall-mounted NEMA 12 enclosures for utility control.

    d. Site-located gate control equipment system enclosure.

2. Control Console:

    a. Custom Control Consoles located in Master Control.

    b. Custom Control Console located in each of two Satellite Control Rooms.

### 1.3 DEFINITIONS

A. AWG: American Wire Gauge

B. NEMA: National Electrical Manufacturers Association

C. SSI: Security Systems Integrator

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies and indicate dimensions, loads, required clearances, and required components.

1. Wiring Diagrams: Power, signal, and control wiring.
2. SSI shall provide complete enclosure design showing the layout of all devices housed within the enclosures.

C. Operation and Maintenance Data: For Cabinets and Enclosures for Electronic Safety and Security system to include in operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

1.6 COORDINATION

A. Coordinate layout and installation of the Cabinets and Enclosure for the Electronic Safety and Security system equipment with existing conditions that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.7 WARRANTY

1. Warranty Period: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SECURITY EQUIPMENT ENCLOSURES

A. Manufacturers:

1. Middle Atlantic
2. Hoffman
3. Hammond

B. Description: This specification describes the Security Equipment Enclosures used for housing Electronic Security System devices. The free-standing enclosures shall house at a minimum, PLC processor equipment, video surveillance head-end, digital intercom head-end, relays, power supplies, network switches and access control equipment. The wall mount racks shall house network switch and video surveillance system equipment. The wall-mounted NEMA 12

enclosures shall house PLC output modules and lighting/receptacle/telephone control relays. The site-located gate control equipment enclosure shall house power supplies, network switches and fiber optic transceivers. SSI shall refer to bid prints for Security Equipment Enclosure locations.

C. Free-Standing Security Equipment Enclosure

1. Provide freestanding equipment cabinets to house 19" rack mountable equipment in the equipment rooms. Each cabinet shall have a rectangular frame with removable side panels and doors. Tops shall accept additional cooling fans if required. Installed cabinets shall include thermal, power, and cable management accessories that control airflow through the cabinet and keep signal and power cables separate and organized.
2. Enclosure shall be vented and provide fan units, as necessary, per the manufacturers recommendations and actual heat loads of the installed equipment.
3. Enclosure shall be rated for a minimum 2500lb UL listed load capacity.
4. Shall be constructed using 14 or 16-gauge steel tops & bottoms and minimum 16-gauge steel frame construction.
5. Provide fully perforated front and rear doors with keyed locks and provide side panels on each end of consecutive modular enclosures.
6. The depth of each enclosure shall accommodate all equipment mounted within. Enclosure shall include a minimum 30-5/8" usable depth. Equipment hindering the closing and locking of any enclosure door will not be acceptable.
7. Enclosure shall include 24-1/4" OD width for cables, 2 extra-wide pair of 10-32 threaded rack rail. Enclosure shall include laser-cut 1/8" thick internal braces for strength.
8. Enclosure shall be finished in a durable black textured power coat.
9. Provide multi-outlet plug strips along the inside of the enclosure as required.
10. Wiring within the enclosure shall be routed within covered wire ways.
11. Enclosure shall have grounding stud installed in base.
12. Approved manufacturers: Middle Atlantic (WRK series) and Hoffman

D. Wall-Mount Rack

1. Center section and backpan shall be 16-gauge steel, phosphate pre-treated and finished in black textured powder coat
2. 150 lb. weight capacity
3. 22" depth
4. Rack shall be mounted for left, or right-hand swing
5. ½", ¾", 1" and 1-1/2" electrical knockouts and 5/8" UHF/VHF antenna knockouts on top and bottom
6. 10-1/2" x 10-1/2" cutout in the backpan for electrical pull-box
7. Front rail adjustable at 1/8", 5/8" and 1-1/8" increments, option available for full front to rear adjustability
8. Front Door shall be vented 68% open area and shall be 16-gauge steel.
9. UL Listed
10. Approved manufacturers: Middle Atlantic (EWR series), AMCO (WMR series)

E. Wall-mounted NEMA 12 enclosure

1. Shall be constructed of 14AWG rolled steel and be NEMA 12 rated.
2. The enclosure shall have a removable 12AWG inner panel for equipment mounting.
3. Door bar on hinge side for wire management and bonding.
4. Mounting holes in back of body for direct mounting or for optional external wall-mounting brackets.
5. Seamless foam-in-place gasket shall provide oil-tight and dust-tight seal against contaminants.
6. Provision for thermoplastic data pocket.
7. Approved manufacturers: Hoffman, Hammond

F. Site-located Gate Control Equipment System Enclosure

1. Shall be constructed of 14AWG Type 304 stainless steel and be NEMA 4X rated.
2. The enclosure shall have a removable 12AWG inner panel for equipment mounting.
3. The enclosure door shall include a padlock adapter for use with a padlock. Door hardware supplier shall provide a padlock for the enclosure door.
4. Approved manufacturers: Hoffman and Hammond

2.2 CONTROL CONSOLES

A. Manufacturer:

1. Xybix (www.xybix.com)

B. Description: This specification describes the new Control Consoles that shall be located at Master Control and each Satellite Control Room. At Master Control the SSI shall provide and install a quantity of two 78” x 44” Dual Surface Control Consoles with true sit to stand adjustable range of 22” – 48” AFF, with T4 Table Base. At each Satellite Control Room, the SSI shall provide and install a quantity of one 72” x 72” Dual Surface Console with true sit to stand adjustment range of 22” – 48” AFF, with T5S Table Base. These control consoles shall be used to house GUI PCs and other associated equipment. They shall be used as working platforms for GUI control, CCTV monitors, audio communication devices and other Owner-provided equipment. The basis of design is Xybix.

C. Control Consoles

1. Each Control Console at Master Control shall consist of the following features;
   a. Xybix 78” x 44” Dual Surface Console with true sit to stand adjustment range of 22” – 48” AFF, with T4 Table Base.
   b. “Rollervision” Monitor Mounting System with 10” of focal depth adjustment. System shall accommodate (2) 24” flat panel monitors on a single tier.
   c. Single shelf with grommet, under monitor surface, 19”W x 5 ¼”H x 9”D with Power-Only USB ports
   d. Data Dock – Keyboard surface cable organizer
   e. Cable Management Bridge for cable organization from desk to CPU cabinet

f. (3) CPU Enclosure, 30” wide, under fixed work surface with front locking access doors, easy access pullout shelf and (2) silent 45 CFM fans for active ventilation. Maximum CPU dimension: 18”H x 7.5”W x 18”D.
g. Single Adjustable Monitor Arm Mounting System accommodating (1) 32” monitor.
h. 48” High sound absorptive panel system. 0.55NRC Rating Standard.
i. SSI shall reference project #20579 with Xybix for complete BOM and pricing information.

2. Each Satellite Control Console shall consist of the following features;
a. Xybix 72” x 72” Dual Surface Console with true sit to stand adjustment range of 22” – 48” AFF, with T5S Table Base.
b. “Rollervision” Monitor Mounting System with 10” of focal depth adjustment. System shall accommodate (3) 24” flat panel monitors on a single tier.
c. Single shelf with grommet, under monitor surface, 19”W x 5 ¼”H x 9”D with Power-Only USB ports
d. Data Dock – Keyboard surface cable organizer
e. Cable Management Bridge for cable organization from desk to CPU cabinet
f. (3) CPU Enclosure, 30” wide, under fixed work surface with front locking access doors, easy access pullout shelf and (2) silent 45 CFM fans for active ventilation. Maximum CPU dimension: 18”H x 7.5”W x 18”D.
g. Single Adjustable Monitor Arm Mounting System accommodating (1) 32” monitor.
h. 48” High sound absorptive panel system. 0.55NRC Rating Standard.
i. SSI shall reference project #20579 with Xybix for complete BOM and pricing information.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Inspect both the substrate and conditions under which work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. SSI shall coordinate with the Owner to confirm that no obstructions exist that would hinder the installation of the required Cabinets and Enclosures.

C. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances. SSI shall coordinate with the Owner to confirm that no obstructions exist that would obstruct the installation.

D. Comply with manufacturer’s installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

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

## 3.2 INSTALLATION

A. Provide Cabinets and Enclosures for the Safety and Security system as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All system equipment to be contained within equipment racks, cabinets, or closets. If more or larger equipment racks or cabinets are required than exist or are indicated in the specifications, allow for such additional equipment racks and cabinets in contract price.

D. Provide adequate ventilation for all heat radiating equipment.

E. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

## 3.3 CONNECTIONS

A. Ground equipment according to manufacturer’s recommendations.

## 3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, and verify the Cabinets and Enclosures for the Electronic Safety and Security system components and equipment installation, including connections, and to assist in field testing.

## 3.5 ADJUSTING

A. SSI shall ensure that all cabinet and enclosure doors and locks are operating properly and that no obstructions exist. Make proper adjustments as necessary.

## 3.6 DEMONSTRATION

A. Provide qualified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the Cabinets and Enclosures for the Electronic Safety and Security system. Refer to Division 01 Section "Demonstration and Training."

B. Training shall be video recorded.

END OF SECTION 280510

# SECTION 284619 – SECURITY AUTOMATION SYSTEM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including General and Supplementary Conditions, and Division 28 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the hardware requirements for the Security Automation System and associated equipment. This shall include all hardware necessary to provide a complete and functional PLC-based GUI control system.

B. The SSI shall provide and install a Security Automation System as specified herein. The system shall include all equipment, installation materials, set up, and testing to form a complete operating system. Independent system functions and integrated system functions to be fully verified as part of system testing and commissioning.

C. All PLC input and output modules shall be distributed and interconnected utilizing an EtherNet/IP bus.

D. The SSI shall provide an electronic interface between the PLC/GUI control system and the Water Management System Server as specified in Division 22. This interface shall provide ON/OFF control of water valves in cells from each GUI station in the system. The Water Management System manufacturer shall provide the SSI with all necessary Software Development Kit (SDK) information necessary to facilitate the interface. The SSI shall provide the necessary PLC/GUI hardware and programming required for this interface.

E. The Security Automation System shall include the following main components:

1. PLC Equipment

2. Power Supplies

3. Relays

4. Fuses

5. Door Release Pushbutton Station

6. Wall-Mount Duress Pushbutton Station

7. Under-Counter Duress Pushbutton Station

8. Under-Counter Door Release Pushbutton Station

9. Motion Sensor

10. Surge Protection Equipment

11. GUI Station Touchscreen Monitors

12. GUI Station PCs

13. Security Management Server & Monitor

1.3 DEFINITIONS

A. GUI: Graphical User Interface

B. PLC: Programmable Logic Controller

C. NEC: National Electric Code

D. DVI: Digital Video Interface

E. VGA: Video Graphics Array

1.4 SUBMITTALS

A. Product Data: Include product specifications, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies with dimensions, loads, required clearances, components, and locations.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: Security Automation System shall be included in operation and maintenance manuals. Include the following:

1. Schedules detailing device names, termination locations, operating voltages, and fuse sizes of all equipment in the system.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

1.6 WARRANTY

A. Warranty Period: 12 months from date of Substantial Completion. The manufacturer shall repair or replace software and hardware that fails in materials or workmanship within specified warranty period.

1.7 EXTRA MATERIALS

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

1. Fuses: Furnish 10 spare fuses of each type provided.

2. Relays: Furnish 5 spare relays of each type provided.

3. PLC input module: Furnish 1 input module of each type provided.

4. PLC output module: Furnish 1 output module of each type provided.

5. PLC processor: Furnish 1 processor of each type provided, including a non-volatile memory card.

6. PLC power supply: Furnish 1 PLC power supply of each type provided.

7. Surge Protector: Furnish 1 spare surge protector of each type provided.

8. GUI Station PC: Furnish 1 spare GUI Station PC and spare 32” Touchscreen Monitor. The PC shall be loaded with the GUI software applications for all GUI station locations. Upon startup, the GUI shall prompt the installer as to what location the GUI is being installed.

PART 2 - PRODUCTS

2.1 PLC Equipment

A. Manufacturer:
1. Omron

B. Description: The PLC system provides the logic control for the Security Automation System. The programmable controller shall interface to the GUI control stations. The PLC executes system commands and operations initiated by the GUI stations. The SSI shall be responsible for all PLC programming and security system integration. All security system related inputs and outputs shall be connected to the PLC I/O network. Hardwired device indication and control relays shall not acceptable.

C. System shall include a complete IEEE 802.3 100/1000 BASE-T Local Area Network that interfaces the GUI control stations, PLCs, Audio Communications Control equipment and the

Digital Video Management System. Network shall be a closed network. Reference section 282300 for network switch requirements.

D. Provide a PLC system that is the product of a single company, which has regularly manufactured PLC equipment for a period of 15 years. Provide components that are regularly used in industrial automation applications. PLC racks and modules shall be DIN rail mountable. The control architecture shall use distributed control over Ethernet. Each controller shall share selected memory with all other controllers via broadcast messages over Ethernet.

E. The SSI shall provide a PLC-controlled relay interface between the SSI-provided control relays and the branch circuits feeding lights and 120VAC receptacles. Control of these relays shall be from the GUI Stations. The SSI shall provide individual or group control of these circuits. Relays in series with “day” lighting circuits shall be wired normally closed. The “night” light circuits shall be wired to the normally open side of the relays. Relays in series with 120VAC receptacles shall be wired normally open. The SSI shall reference the Division 28 plans and specifications for relay control panel schedules and the Division 26 plans for panel board schedules.

F. PLC Processor
   1. The PLC processor shall be an industrial rated controller capable of executing a basic cycle of instructions in less than 100 milliseconds.
   2. The processor shall be capable of supporting 50,000 steps of programming and 160,000 words of data memory.
   3. The processor shall utilize input and output modules of the same manufacturer to connect to security devices in distributed security equipment enclosures.
   4. The processor shall have an embedded Ethernet port for communication to the GUI control stations.
   5. The SSI shall provide a non-volatile memory card for each PLC processor provided.
   6. The SSI shall configure the PLC to allow for programming using a connection to the facility’s security network.
   7. For systems with multiple PLC processors, failure of any PLC or PLCs shall not impact the operation of those remaining operational except to the extent that remote indications from the failed PLC may be lost.

G. PLC Input and Output Modules
   1. I/O modules shall be distributed and interconnected utilizing an EtherNet/IP bus.
   2. The I/O modules shall have LED indicators that reflect the state of each input or output point.
   3. The I/O modules shall be capable of being replaced without the need to unwire field connections. All field wiring shall remain intact on removable connectors.
   4. At each location that I/O is installed, provide a minimum of 10% spare input points and 10% spare output points.
   5. Upon loss of power, faults, or communication failures with PLC I/O modules, all electric locks shall fail-secure. Sliding and overhead doors shall remain in their present state.

H. Security Interface
   1. Owner shall provide a high-speed internet connection for use by SSI.

I. PLC Software

1. SSI shall provide the Owner with a licensed copy of the latest version of the PLC programming software. All necessary software to program and configure the PLC system shall be included with the software package. This software shall be installed on the Security Management Server. System program files and documentation shall be included with the programming software.

## 2.2 POWER SUPPLIES

A. Manufacturers:
   1. Mean Well
   2. Omron
   3. PULS

B. Description: Din-rail mountable power supplies for powering the PLC equipment, electric locks and other related security devices. The basis for the specification is Mean Well.

C. 24VDC Power Supply
   1. Rated for 120VAC input and 240W output
   2. Short Circuit/Over-load/Over-voltage/Over-temperature protection with self-correction after fault is removed
   3. Din Rail Mountable
   4. UL508 (industrial control equipment) approved
   5. LED indication for power on

## 2.3 RELAYS

A. Manufacturers
   1. Omron
   2. Allen-Bradley
   3. Eaton

B. Description: Relays shall be connected to the discrete outputs from the PLC and connect to field devices for signaling and control.

C. Door Control Relay
   1. Coil rating of 24VDC @ 21mA
   2. Contact rating of 250VAC @ 5A
   3. Power consumption of no more than 0.5W
   4. Slim socket design to allow for quick replacement.
   5. LED for indication

D. Offender Telecommunication Circuit Control Relay
   1. Coil rating of 24VDC @ 21mA
   2. Contact rating of 250VAC @ 5A
   3. Power consumption of no more than 0.5W
   4. Slim socket design to allow for quick replacement.

5. LED for indication
6. Double-pole, double-throw

E. Lighting/Power Circuit Control Relay: Provide SPDT relays per the application requirements. Reference Division 26 panel schedules and coordinate with the Division 26 contractor for exact requirements. The relays shall include the following features:
1. Contact material: Silver Alloy
2. Current rating: 20A
3. Maximum Switching Voltage: 300V
4. Electrical Life: 100,000 operations @ rated current (resistive)
5. Switching Current @ Voltage (Resistive): 20A @ 277V 50/60Hz
6. Switching Current @ Voltage (HP): 1 @ 277V
7. SPDT

## 2.4 FUSES

A. Manufacturers
1. Allen Bradley
2. ABB
3. Sprecher + Schuh

B. Description: To ensure system integrity, all primary and secondary circuits shall be fused according NEC guidelines. A fuse shall be provided for each door control relay. Each fuse shall be uniquely labeled with an identifier. Each equipment cabinet containing fuses shall contain a “Fuse Schedule” sheet posted inside the door listing all fuses by the appropriate identifier and specify the operating voltage and fuse size for each

C. 24VDC FUSE HOLDER
1. 5mm Din rail mounted fuse holder with screw clamps
2. Rated for 250V @ 10A
3. Shall be UL recognized
4. LED indication

D. 120VAC FUSE HOLDER
1. 17.5mm Din Rail mounted with screw clamps
2. Rated for 600V @ 30A
3. Shall be UL recognized

## 2.5 DOOR RELEASE PUSHBUTTON STATION

A. Manufacturers:
1. Quam
2. Harding Instruments

B. Description: The Door Release pushbutton stations shall consist of wall-mounted detention grade stainless steel wall plates containing crushproof pushbuttons where shown on the Security Drawings.

C. Door Release Pushbutton Station
   1. Single-gang, vandal-resistant 12GA brushed stainless steel faceplate
   2. Momentary, normally open, pushbutton.
   3. Mounted using #6-32 security screws
   4. Laser engrave the text “DOOR RELEASE” into the faceplate

## 2.6 WALL-MOUNT DURESS PUSHBUTTON STATION

A. Manufacturers:
   1. Allen Bradley
   2. Sprecher + Schuh
   3. GE

B. Description: The wall-mounted Duress Pushbuttons shall consist of a red illuminated mushroom-head pushbutton mounted to a detention grade stainless steel wall plate.

C. Wall-Mount Duress Pushbutton Station
   1. 30mm illuminated mushroom-head button with push-pull operation.
   2. Normally-closed, screw clamp, contact blocks
   3. Illumination via LED not incandescent bulbs
   4. Single-gang, vandal-resistant 12GA brushed stainless steel faceplate
   5. Engrave the text “DURESS” into the faceplate.

## 2.7 UNDER-COUNTER DURESS PUSHBUTTON STATION

A. Manufacturers:
   1. Potter
   2. Ademco
   3. GE

B. Description: Under counter pushbutton shall function as a duress signaling device to the Security Automation System. These devices shall be mounted under millwork out of public view so that they can be activated inconspicuously. The basis for the specification is Potter.

C. Under-Counter Duress Pushbutton Station
   1. Dimensions no greater than 2”W x 2 5/16”L x 1”H
   2. Can use maintained contacts (latching) or momentary contacts.
   3. Equipped with both Normally Open and Normally Closed contacts.
   4. Switch rating of 3A at 28VDC

## 2.8 UNDER-COUNTER DOOR RELEASE PUSHBUTTON STATION

A. Manufacturers:
   1. Alarm Controls (ASSA ABLOY)
   2. Potter
   3. GE

B. Description: Under counter Door Release pushbuttons shall provide a means of unlocking an electrically controlled door from a desk or countertop. The basis for the specification is Alarm Controls.

C. Under-Counter Door Release Pushbutton Station
   1. Dimensions no greater than 1-1/2”W x 2”L x 1”H
   2. Equipped with both Normally Open and Normally Closed contacts.
   3. Configured for momentary pushbutton operation
   4. Switch rating of 4A at 28VDC

## 2.9 MOTION SENSOR

A. Manufacturers:
   1. Bosch
   2. Honeywell

B. Description: Motion Sensors shall be provided in cell chase areas as shown on the plans. Active motion alarms shall annunciate on GUI stations per their area of coverage. The basis for the specification is Bosch.

C. Motion Sensor
   1. Dimensions: 8.5cm x 13.3cm (3.5” x 5.25”)
   2. Material: High impact ABS plastic enclosure
   3. Operating Temperature: -40°C to 49°C (-40°F to 120°F)
   4. RFI Immunity: No alarm or setup on critical frequencies in the range from 26 MHz to 950 MHz at 50 V/m
   5. Alarm Output: Form C reed relay rated at 3.0W, 125mA at 28VDC for resistive load
   6. Tamper Output: Normally-closed tamper switch. Contacts rated at 28VDC, 125mA max.
   7. Power Requirements: 6-15VDC, 18mA standby, 75mA in alarm
   8. Provide Bosch model DS9360

## 2.10 SURGE PROTECTION EQUIPMENT

A. Manufacturers:
   1. Transtector Systems
   2. Emerson Network Power
   3. Ditek

B. Description: Surge Protectors shall provide high speed transient protection for all security system power circuits as well as signaling and communication circuits for devices located exterior to the building. The basis for the specifications is Transtector Systems and Ditek.

C. 120VAC Surge Protection (Din-Rail Mount)
   1. Transtector Systems model DR120
   2. The 120VAC surge protector shall include the following features:
      a. Solid State device, utilizing Silicon Avalanche Suppressor Diodes

b. The suppressor shall wire in parallel with the load and may be removed from its base without interrupting the protected circuit.
c. The device shall be din-rail mounted and accept 12-28AWG wiring.
d. LED signal indicating suppressor operation.

D. 48 PoE RJ-45 Surge Protector
1. Ditek model DTK-MRJPOE
2. Ditek model DTK-RM12POE
3. Surge protector shall be used for each PoE camera located on the exterior of the building. Surge protectors shall be located in the security equipment head-end rack location(s).
4. The PoE surge protector shall include the following features:
a. Service Voltage: <60V
b. Protection Modes: L-G (All), L-L (All)
c. Clamping Voltage Common Mode: 75V
d. Clamping Voltage Differential Mode: 72V
e. Surge Current Rating: 20kA/Pair
f. Max. Continuous Current: 1.5 Amps
g. Power Handling: 144 Watts
h. Data Rate: Up to 10GbE
i. Connection Method: RJ45 In/Out
j. Housing: ABS
k. Operating Temperature: -40°F to 158°F (-40°C to 70°C)
l. Maximum Humidity: 95% non-condensing

E. Intercom/Card Reader Surge Protection
1. Ditek model DTK-2LVLPLV
2. Surge protector shall be used for each intercom station or card reader mounted on the exterior of the building.
3. The intercom/card reader surge protector shall include the following features:
a. Protection Modes: Line-Ground (All)
b. Surge Current Rating: 2,000 Amps per pair (5V –48V), 9,000 Amps per pair (75V – 130V)
c. Max. Continuous Current: 5 Amps, 0.15 Amps (SCP)
d. Connection Method: Screw Terminals, #22-#16AWG
e. Housing: ABS
f. Operating Temperature: -40°F to 158°F (-40°C to 70°C)
g. Maximum Humidity: 95% non-condensing

## 2.11 GUI STATION TOUCHSCREEN MONITORS

A. Manufacturers:
1. ELO
2. Planar

B. Description: Each GUI Station PC shall include one touchscreen monitor. Provide 24" touchscreen monitors for the Booking Counter and Medical Area Work Station. All other control locations shall be provided with 32" touchscreen monitors.

C. 24" LED Monitor - The 24" monitors shall have the following features:
1. Touch Technology and Capacity: Projected Capacitive – 10 Touch
2. Diagonal Size: 23.8" diagonal, active matrix TFT LCD (LED)
3. Aspect Ratio: 16:9
4. Active Area: 20.75" x 11.67"
5. Resolution: 1920 x 1080 @ 50, 60Hz
6. Viewing Angle: Horizontal: ±89° or 178° total / Vertical: ±89° or 178° total
7. Number of Colors: 16.7 million
8. Response Time: 15 msec
9. Contrast Ratio: 1000:1
10. Touch Interface: USB
11. Input Video Format: VGA and HDMI
12. Speakers: Two x 2W internal speakers
13. Provide ELO Model 2402L, P/N E351806

D. 32" LED Monitor - The 32" monitors shall have the following features:
1. Touch Technology and Capacity: Projected Capacitive – 12 Touch
2. Diagonal Size: 31.5" diagonal, active matrix TFT LCD (LED)
3. Aspect Ratio: 16:9
4. Active Area: 27.49" x 15.47"
5. Resolution: 1920 x 1080 @ 60Hz
6. Viewing Angle: Horizontal: ±89° or 178° total / Vertical: ±89° or 178° total
7. Number of Colors: 16.7 million
8. Response Time: 8 msec
9. Contrast Ratio: 3000:1
10. Touch Interface: USB
11. Input Video Format: VGA and HDMI
12. Speakers: Four x 5W stereo speakers
13. Provide ELO Model 3202L, P/N E222368
14. Provide desktop stand for countertop mounting

## 2.12 GUI STATION PC

A. Manufacturers:
1. Logicsupply.com
2. Teguar

B. Description: Industrial Fanless Computer utilizing the HMI software to communicate with the PLC to control and monitor security system functions. The basis for the specification is Logicsupply.com. This computer shall meet the following minimum specifications:
1. Processor: Intel Core™ i7-8650U (1.9GHz Quad Core Processor)
2. OS: Windows 10 Professional, 64-bit
3. Memory: 16GB SO-DIMM DDR4

4. Hard Drive: 128GB M.2 SSD
5. Wireless Keyboard & Mouse: Logitech Model MK320
6. Provide Logicsupply Model ML100G-31, or approved equal

2.13 SECURITY MANAGEMENT SERVER & MONITOR

A. Manufacturers:
1. Dell
2. HP

B. Description: The Security Management Server shall record all events that take place within the Electronic Security automation system PLC and GUI. The basis for the specification is Dell. Reference section 284620 for software requirements. The Server shall meet the following minimum specifications:
1. Processor: Intel® Xeon® E3-2134 3.50 GHz, 8M Cache, Turbo, Quad Core/8T
2. OS: Windows Server 2019 Standard
3. SQL Server 2017 Standard Edition
4. Memory: 16GB
5. Network Adapter: Dual GB NIC
6. Hard Drive: (2) 2TB 7200RPM SATA Drive (configured for RAID 1)
7. Internal Controller: S140 (software RAID)
8. Removable Media: DVD-RW drive
9. Integrated display video adaptor
10. Dell basic keyboard
11. Dell 2-button optical USB mouse
12. Dell 22” LCD monitor, model E2219H
13. Lexmark Laser printer, model MS321dn

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect the conditions under which work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances.

C. Comply with manufacturer’s installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

D. Protection shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

3.2 INSTALLATION

A. Provide complete Security Automation System as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All system equipment to be contained within equipment racks and cabinets. If more or larger equipment racks or cabinets are required than exist or are specified, allow for such additional equipment racks and cabinets in contract price.

D. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

E. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

F. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

G. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

3.3 CONNECTIONS

A. Ground equipment according to manufacturer’s recommendations.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: A trained service representative to inspect, test, and adjust PLC system components and equipment installation, including connections, and to assist in field testing.

B. Perform the following field tests and inspections and prepare pass/fail reports:

1. Field Device Test: SSI shall perform an inspection of each field device connected to the PLC system to ensure that each is properly working, installed, and configured for its particular location.
2. The SSI shall also verify that all PLC events are being logged to the Security Management Server

C. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

A. A trained service representative will perform system maintenance training at the Owner’s facility once the final inspection is complete.

B. Training shall be video recorded.

END OF SECTION 284619

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# SECTION 284620 – VIDEO GRAPHIC USER INTERFACE

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including General and Supplementary Conditions, and Division 28 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the requirements for the video graphic user interface (GUI). The GUI software shall be the primary interface to the PLC and Electronic Security System. The GUI software operating on the GUI Station PCs shall communicate to the PLC processors for security systems operation.

B. The GUI software shall be programmed and configured to provide all functionality as described in this specification section. The GUI software shall communicate with all required security system components to display, control and monitor all security devices as specified and shown on the plans.

C. GUI stations shall be provided as shown on the plans. The GUI stations in Master shall be designated as the “Master GUI stations” and shall have the ability to take over all functions and disable/enable all other GUI station locations. The GUI stations at Intake and Medical shall have no door control functionality, but shall include all other functionality pertaining to their respective areas.

D. The video graphic user interface shall include the following main components:

1. HMI Development Software
2. Door Control
3. Video Monitoring
4. Intercom Communication
5. Utility Control
6. Area Notes
7. Duress Alarms
8. Emergency Features
9. Additional GUI Features

10. Security Management Server Software

1.3 DEFINITIONS

A. GUI: Graphical User Interface

B. PLC: Programmable Logic Controller

C. HMI: Human Machine Interface

1.4 SUBMITTALS

A. Product Data: Include software datasheets, operating characteristics, and accessories required.

1. Shop Drawings: Provide all Graphical User Interface layouts. Layouts shall be created by the GUI configuration software and shall not consist of line drawings created by CAD programs. The Owner reserves the right to request the Division 28 SSI to make changes (during the submittal process) to the GUI layouts based on the Owner's policies and procedures, without incurring any additional cost to the Owner.

B. Operation and Maintenance Data: Include the following:

1. Detailed operations manual describing all features of the GUI including all administrative features.

2. Schedules detailing IP address, model numbers, locations, titles, and termination locations of all GUI stations in the system.

1.5 QUALITY ASSURANCE

A. All GUI development shall be done by a Certified Partner of the HMI manufacturer and adhere to all recommended development standards.

1.6 WARRANTY

A. The SSI shall warranty the GUI software to be free of defects for a period of 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 HMI Development Software

A. Manufacturer:
   1. Omron Indusoft

B. Description: The GUI application(s) shall be developed using a non-proprietary industrial development suite designed for real-time connections to PLCs and other types of remote I/O devices. The development environment shall allow for the creation of animated operator interface screens utilizing an application tag database.

C. HMI Development Software
   1. The HMI shall support the number of I/O tags as required for each application in the system.
   2. The HMI shall allow for sophisticated scripting for customizing applications for specific needs.
   3. The HMI shall allow for Microsoft ActiveX controls and .NET controls integration.
   4. The HMI shall allow for resolution independent graphics and intelligent symbols.
   5. The HMI shall allow for template-based development of objects and graphics.

D. HMI Screen Development
   1. Provide screens utilizing accurately depicted, properly aligned floor plans. Floor plans shall be displayed as seen from the GUI control station operator's perspective.
   2. Provide screens that incorporate the use of screen resolution and color to enhance and simplify the information displayed. Provide a light gray background for all screens. Provide screens that utilize contrasting colors. GUI screens shall use red for alarm conditions, yellow for cautionary conditions and information such as the depiction of interlock groups, use green for audio communication functions and blue for video surveillance.
   3. Provide the number of screens that support the sequences of operation as required by the system.

2.2 DOOR CONTROL

A. DOOR ICON – The Door Icon shall activate a door menu which appears next to the selected door icon and contains all functions available for that particular door. Possible functions include: UNLOCK, HOLD OPEN, CLOSE, INTERLOCK OVERRIDE, ISOLATE, and ALARM CLEAR. While the door is selected, a BLUE (flashing) selection ring shall surround the door icon showing the operator which door is under their control. Only after the door has been selected can any other function be selected. This two-keystroke operation for unlocking is important so that doors cannot be accidently unlocked. The same control methods are required for swing, sliding, and overhead doors. When the operator selects a door menu function the GUI shall audibly announce which function was selected. To unlock a door, the operator must first select the door, then from the door menu select the "UNLOCK" function. The GUI will then announce "Unlock", if the door was a swing door then the door will be unlocked for 3 seconds and then automatically relock. If the door was a sliding door or an overhead it will open fully

and stop. To stop the opening or closing of a sliding or overhead door the operator can press the “STOP” button which will stop the motion of the traveling door. To hold a swing door open or unlocked, the operator shall first select the door and from the door menu select “HOLD-OPEN”. The door will remain in the unlocked position until the operator selects the door and presses the “CLOSE” button. To close a sliding or overhead door, the operator shall first select the door and from the door menu select the “CLOSE” button. The selected door will then close completely. If a door is selected but no menu function is pressed the door menu will time-out after 5 seconds and disappear.

1. DOOR MENU - When a Door Icon is selected a menu shall appear next to the icon and contain all functions available for that door. Such functions shall include UNLOCK, HOLD OPEN, CLOSE, INTERLOCK OVERRIDE, ISOLATE, and ALARM CLEAR. If no selection is made within 5 seconds the door menu shall timeout and disappear.

2. DOOR INDICATION - The Door Icon shall include a symbolic representation the status of the door. The door symbol should represent the door and its current state (i.e. opened, closed, unlocked, etc). Swing door icons shall look like swing doors opening and closing during operation, sliding doors shall appear to slide open and closed during operation, and overhead door icons shall look like overhead doors opening and closing during operation. The Door Icon shall have the following states:
   a. The door icon button is gray and the door symbol is gray when the door is locked and secured.
   b. The door icon button is red and the door symbol is gray when the door is powered but the lock status switch and the door position switch are still indicating that the door is secure.
   c. The door icon button is red and the door symbol is red when the door is powered and unsecure.
   d. The door icon button is gray and the door symbol is red when the door is not powered but is unsecure.
   e. The door icon button flashes red and the door symbol shows the current status of the door if the door is violated. A door shall be considered ‘violated’ if it is opened by any other means than the Security Automation System. The GUI shall annunciate “DOOR VIOLATION” until the alarm is acknowledged.
   f. Interlocked doors shown with yellow outlines around their buttons when a door in an interlock group is unsecure. If an interlocked door is attempted to be unlocked, the GUI shall annunciate "Not allowed, door is interlocked."

3. DOOR GROUPS - Doors can also be configured into groups. The Door Groups shall be controlled using the “GROUP” button located within the GUI. To control a group of doors the operator shall first select the appropriate “GROUP” icon which displays the Group Menu. From the menu the operator can select to “UNLOCK”, “HOLD OPEN”, or “CLOSE” all doors in that group.

4. DOOR ISOLATE - Electrically controlled doors can be isolated such that they cannot be opened from the GUI or from other field devices such as pushbuttons, proximity readers, or motion detectors. To isolate a door, the operator first selects the door which

displays the door menu. From the menu, the operator selects “ISOLATE” which places a large red “X” on the door icon. Once isolated, all door unlocking functions will not be available. This feature is also used to isolate doors from being unlocked using the Group Unlock function. The door remains isolated until the operator selects the door and presses the “ISOLATE” button again which removes the large red “X” from the door icon.

5. INTERLOCKS - Interlock groups as defined by the Owner shall be configured as a function of the Security Automation System. These interlock groups are to be programmed into the PLC and not be hardwired or mechanical and are intended to allow only one door in a group to be unlocked at any one time.
   a. When a door in an interlock group becomes unlocked or unsecured all doors in that group including the unsecure door will be shown with a yellow outline around the icon. This denotes an “active interlock”.
   b. If the operator tries to unlock a door in an active interlock the GUI shall audibly tell the user “Denied, Door is Interlocked”.
   c. Active interlocks shall be displayed on all GUI stations regardless of whether they are in primary control of that area.
   d. To unlock a door within an active interlock group, the operator must use a minimum of two steps to unlock a door.
      1. First select “Interlock Override” from the Door Menu. The GUI shall audibly warn the operator of the risks involved in the action.
      2. The operator must then select “CONTINUE” to override the interlock. The system shall allow the user to unlock one door in the interlock group then reactivate the active interlock group
   e. When all doors in an interlock group are secured the yellow outlines shall disappear.

6. EXTERIOR DOOR CONFIRMATION - The GUI software shall be configured to require a second confirmation step before unlocking exterior doors. After the operator attempts to perform the Unlock command a window shall appear asking the operator to acknowledge the security risk in unlocking an exterior door. The operator must press the YES – UNLOCK button before the system will unlock the door. The other option is to press the NO – ABORT button, which will cancel the function.

## 2.3 VIDEO MONITORING

A. Video monitoring from the GUI is accomplished by selecting any VIDEO CAMERA ICON. Each Video Camera Icon represents a camera within the system. The orientation of the camera symbol shall be representative of the actual direction of the camera. Once selected, the icon will turn from gray to blue and the video image of the camera will be displayed live within an onscreen video display window. Two onscreen video display windows shall be incorporated into the GUI. One window shall be used for manual camera call-up and the other window shall be used for intercom follow. Selecting another camera icon shall cause its camera to become active and cancel the previous camera. When cancelled, the camera icon shall change from blue, back to gray. To populate a video display window with a selected camera image, the operator shall right-click on the selected VIDEO CAMERA ICON and a pop-up menu shall display a graphical view of the available video display windows. The operator shall then be

able to select the desired video display window to populate with the selected camera. For the two video windows dedicated to manual camera call-up and intercom follow, pressing any Video Camera Icons (or an active intercom follow) will override any camera being displayed.

## 2.4 INTERCOM COMMUNICATION

A. Establishing Intercom audio communications from the GUI is accomplished by selecting any INTERCOM ICON. These icons shall be placed on the floor plan at the location of each intercom station. Selecting the icon will immediately activate the intercom station and allow the control station to monitor the audio at the station. The Intercom icon will turn from gray to green upon activation and the station ID# is displayed in the "IN USE" field of the GUI. Pressing the "Push-To-Talk" button located at the GUI station shall allow the operator to communicate with the intercom station. Pressing the active Intercom icon again will cancel the connection. Pressing another Intercom icon will automatically connect the operator to that station and cancel the previous connection. If there is a camera in view of the intercom station it shall be automatically connected to the video display window (reference 2.3, A). When connected the Video Camera Icon camera symbol shall display a green indicator showing that it has been called up following the intercom connection. The Intercom Icon shall have the following states:

1. If an intercom call button, located on or at the intercom station, is pressed the INTERCOM ICON flashes green and the GUI shall sound a call notification until the call is connected or the ACKNOWLEDGE button is pressed.
2. Once the call is answered, the INTERCOM ICON shall turn solid green. If another call is incoming while the first is being serviced, that INTERCOM ICON shall flash but the GUI shall wait to annunciate the call notification until the current active intercom is disconnected.

B. ISOLATE INTERCOM – This feature allows the operator to remove the intercom stations ability to audibly call the GUI station. To isolate a station, the operator must first press the "ISOLATE INTERCOM" button then select which station(s) to isolate. The first time the icon is pressed a large red "X" is placed on the Intercom icon denoting it as isolated. The GUI software shall allow the user 3 seconds to select other stations before timing out. To remove the isolation the user shall repeat the process which will remove the large red "X" from the icon.

C. AUDIO LEVEL MONITORING: This feature shall monitor the audio levels in predetermined areas and provide notification when the audio level exceeds the present setting. When the level is exceeded the intercom shall sound the call notification, flash the intercom icon, and display the text "ALARM" in red letters on the intercom icon.

D. INTERCOM AUDIO WINDOW – There shall be an Intercom Audio window integrated into the control menu for displaying the status of the intercom audio system. A portion of this window shall indicate which intercom station is currently active. In addition, there shall be a pending list displaying the 6 oldest intercoms in the queue. To answer a pending intercom the operator can either select the flashing intercom icon or select it out of the queue. Selecting the intercom out of the queue connects the operator to that station and its station ID# shall appear in the "In Use" field of the intercom audio window. Furthermore, when the station is selected out of the queue the GUI shall automatically switch the operator to the screen that contains the active intercom. To disconnect, the operator can simply press the station ID text in the "In Use" field or press the active intercom icon.

2.5 UTILITY & MISC. CONTROL

A. Utility control is a menu function that once selected displays all Light Icons, TV Receptacle Icons, Water Valve Control Icons and Inmate Telephone control Icons. Water Valve Control Icons shall be placed on the GUI screens at each cell location that includes controlled water valves. There shall be one Icon for each group of valves per cell. The GUI software shall give the operator 5 seconds to select an icon before it is hidden. During this time period, all Intercom Icons and Paging Icons shall be hidden in the background. Once an icon is selected, the timer shall start over and allow 5 more seconds before hiding the icons. Selecting a Utility Icon while the function is active shall cause the utility to turn “ON” if it is “OFF” and “OFF” if it is turned “ON”. Utilities groups can also be controlled using the “GROUP” button while the menu selection is still active and the icons are visible. Pressing the “GROUP” button once shall turn all utilities “ON” and pressing again shall turn them all “OFF”.

B. During an emergency evacuation event or other emergency occurrence, all lights in the area of the event shall be configured to turn ON (if configured to be controlled via the PLC GUI system).

C. PROXIMITY READER ICONS – Proximity Reader Icons shall be placed on the GUI screens where proximity readers are located. When a proximity reader has a valid credential read that provides access for the user, the Proximity Reader Icon shall turn green for 3 seconds. Proximity Readers shall be able to be isolated (or disabled). When the icon is pressed a large yellow “X” is placed on the Proximity Reader icon denoting it as isolated. To remove the isolation the user shall repeat the process which will remove the large yellow “X” from the icon.

2.6 AREA NOTES

A. The GUI shall allow operators to enter notes on each cell, dorm or other significant area and save these notes to the data-logging system database. The operator shall be able to enter text using the attached keyboard or onscreen touch keyboard. Once saved, the note shall be logged with the operator name in the database.

1. Viewing Area Notes:
    a. To display all available AREA NOTES ICONS, the operator shall first press the “SHOW NOTES” menu button. To hide the Area Notes Icons in the background, the operator shall press the “SHOW NOTES” button again.
    b. Each cell or other location that has the Area Notes feature available shall display an icon in the shape of a notepad.
    c. When text has been entered and saved in an Area Note, the icon shall provide a clear, visible indication that there is information associated with the Area Note. When no information is available for the Area Note, the icon shall provide a clear, visible indication that there is no information available.

2. Displaying and Entering information into an Area Note:
    a. Clicking the Area Note Icon will display a menu next to the icon.
    b. The menu shall contain two fields for displaying/entering characters. Each field shall

be capable of displaying 50 characters.

c. After the characters are entered, the operator shall be able to store the note to the data-logging system database by pressing the ACCEPT UPDATES button on the menu.

d. After the ACCEPT UPDATES button is pressed, the menu for the Area Note shall be hidden in the background.

e. The area note shall be no more than 130 characters.

f. To erase the characters stored in the note, the operator shall be able to press the ERASE button.

g. To close the menu, the operator shall press the CLOSE button.

## 2.7 DURESS ALARMS

A. DURESS ALARM ICONS shall be placed on the GUI screens that represent the physical locations of actual duress pushbuttons stations around the facility. Duress Alarm Icons shall normally be hidden when not active. When a duress alarm pushbutton station is pressed the Duress Alarm Icon shall be displayed and shall flash. The GUI shall annunciate “OFFICER ALARM” until the alarm is acknowledged. Once the alarm is acknowledged, the icon shall continue to flash with no audible alarm until the actual physical pushbutton station is reset by releasing the latched pushbutton. Once the pushbutton station is reset the icon shall be hidden in the background.

## 2.8 EMERGENCY FEATURES

A. EMERGENCY MENU: Located on GUI menu shall be a button labeled “EMERGENCY.” Pressing this button will display the Emergency Menu which consists of various emergency related function buttons. These buttons shall include: RELEASE ALL, and LOCKDOWN.

1. RELEASE ALL button:

a. When pressed, this button shall begin the Emergency Evacuation sequence and display a window explaining the risk of the action. The GUI shall also audibly warn the operator of the risks involved in continuing the action. On the step 1, window there shall be buttons to CONTINUE and ABORT.

b. If the operator continues, the first window shall disappear and a second window shall again warn of the danger and risks involved in continuing. Also the GUI shall place “E” symbols on all controlled doors that will be released and again warn the operator of the dangers involved in continuing. On the step 2 window, there shall be buttons to CONTINUE and ABORT.

c. If the operator chooses to continue, a full screen window shall appear stating that this is the final warning before release. An audible message shall warn the operator that after this step, all doors with “E” symbols will be released. On the step 3 window, there shall be a button to CONTINUE and the ABORT button should at least 10 times larger in size.

d. Pressing continue will begin the unlocking sequence, all doors with “E” symbols will be released or opened.

2. LOCKDOWN button: The Emergency Window shall contain a LOCKDOWN button. This button shall lock all held-open swing doors as well as close all sliding and overhead doors. This feature shall also disable all access devices such as proximity readers and door release pushbuttons.

## 2.9 ADDITIONAL GUI FEATURES

A. NAVIGATION PANE – There shall be a portion of the GUI screen dedicated to screen navigation for the Security Automation System. This shall be a graphical representation of the floor layout segmented to represent each screen. This area is also used to display Door Violation Indication, Alarm indication and Pending Intercom indication. When a door on particular screen violates the screen associated with that door flashes red indicating to the operator that their attention is required. Other devices that should be indicated by a red flash in the Navigation Pane include: Fire Alarm System Annunciation. Pending Intercom stations shall flash their respective windows green to help assist the operator in finding the pending station. The current active screen shall be displayed as white allowing the user to see their current location

B. ALARM ACKNOWLEDGE - Selecting this icon shall acknowledge and silence the audible notification used to indicate a violated door, intercom station call, or any other alarm.

C. CONTROL ROOM DURESS - Selecting this icon shall immediately DISABLE all functions of the GUI. This feature shall be included on GUI stations outside of Master Control.

D. ADMINISTRATIVE UTILITIES MENU - Located on the menu shall be a button for configuring convenience and maintenance options to the operator.

1. A ‘COMMAND FUNCTIONS’ button shall allow the operator to shut-down the GUI software applications. Upon selecting the button, the operator is prompted to provide an administrator-level password before the software applications are shut down.
2. A ‘VOICE STYLE’ selection shall allow the operator to select between a female, male, or basic for common GUI functions. For audible alarm indications, the GUI shall play a male or female voice always.
3. A ‘CALIBRATE SCREEN’ button shall allow the operator to calibrate the GUI overlay for proper touch alignment.
4. A ‘CLEAN SCREEN’ button shall allow the operator to clean the surface of the GUI display with a manufacturer approved cleaning product. The screen shall be “blanked” so that no icons or control functions are available to the operator. An onscreen message shall tell the user what types of cleaning products are approved.

## 2.10 SECURITY MANAGEMENT SERVER SOFTWARE

A. All events that take place within the PLC and Electronic Security System shall be logged to a Security Management Server provided by the SSI. The HMI software installed on the GUI stations shall not be dependent on the security management server and software. The loss of functionality of the security management server shall in no way affect the normal operation of the GUI software.

B. The security management server shall have the following features:
   1. Record Device Events for the following field devices:
      a. Doors
      b. Intercoms
      c. Proximity Readers
      d. Cameras
      e. Utility Control (Lighting, TV Receptacle, Water Valve, Inmate Phone control)
      f. Misc. Alarms (Duress, etc.)
      g. Any other project-specific device
   2. Record Control Point events for each GUI station. These events shall be visibly different from Device Events and display which control point and which user initiated the event. A control point shall consist of events generated by a GUI station. Control Point events shall include the following events;
      a. Area Notes
      b. Touchscreen Status
      c. Interlock Override
      d. Emergency Evacuation
   3. The software shall allow the user to enter a credential, or 4-digit pin for each GUI station.
   4. The Event log shall include 'Area Notes' logged by each GUI station. The GUI operator shall have the ability of selecting a cell or room and typing a note that is to be displayed on GUI as well as logged in the security management software. The software shall allow up to 131 characters to be entered and stored. The Area Note shall have a specific device name, or specific location associated with it so that it can be easily searched.
   5. Event log shall be stored in a SQL database and be archived for retrieval.
   6. The security management server shall provide the user the ability to display the previous 100, 50 or 25 events dynamically updating on the screen.
   7. The security management server shall provide the user the ability to adjust the refresh rate for the events at a rate of 10 seconds, 30 seconds, 60 seconds or 5 minutes.
   8. The user shall be able to filter the dynamic event display by device type.
   9. The dynamic event display shall display columns for Control Point/User, Recorded Audio File, Timestamp (the date and time of the event), Device Name, Event Type, Device Description/Note, Device Type, Area Name (location area name the specific device is grouped in).
   10. The user shall be able to generate reports based on database queries for event names or time of occurrences. This report shall be displayed on screen and the user should be allowed to print the report.
   11. Devices and their associated events shall have the ability to be grouped based on their respective locations in the building. (i.e. Cell Block A, B, C, Booking, etc.)
   12. The user shall have the ability of performing a search function that looks for keywords such as type of event, area of the building, or device names. The search function will replace the dynamic event view with the returned list based on the search criteria. The user can either choose to see the previous 100 events (based on the search criteria) or all events containing the keyword(s) searched.
   13. Provide e-mail notification that includes the following functionality:
      a. Manage rule definitions, that when evaluated as true, will send an e-mail.

b. Each rule can be based on any combination of LT Timestamp, Device Name, Event Name, Device Description, Device Type Name, Area Name, Control Point Name, Username, URL, and Note.
c. Rule start time and end time can be defined.
d. Rules can have custom messages attached to email alert.
e. Each rule can be based on device or control point events.
f. Each rule can be associated with one or more email addresses.
g. Each email can be associated with one or more rules.
h. System shall have the ability to send notification emails to a defined email server via SMTP.
i. System shall log notification events and the operator shall be able to view them through the Monitor client application.

14. Provide an audio playback feature that includes the following functionality:
    a. Each active audio connection (conversation) between an intercom station and a GUI station shall be recorded to the security management server as a single MP3 audio file.
    b. In the dynamic event display, there shall be a column for a recorded audio conversation. If an audio file is associated with the intercom connect event, the system shall display a speaker symbol.
    c. If the speaker icon is selected, a “Play Audio” menu shall be displayed. On the menu screen, the Device Name, the Event Timestamp and the Control Point Name/User shall be displayed.
    d. The Play Audio menu shall allow the user the choice of pressing “PLAY” to play back the audio file directly on the server, pressing “STOP” to stop the playback, or pressing “EXPORT AUDIO” to export the audio file to a location on the server selected by the user.
    e. Along with the “PLAY” and “STOP” buttons, the Total Duration of the sound file shall be displayed. The Current Position (dynamically displayed) and Current Ending location of the sound file shall also be displayed. All times shall be displayed in minutes and seconds.
    f. The Play Audio menu shall include a progress bar that visually indicates where in the recorded audio file the playback is currently at. There shall be two adjustable markers (“start” and “end”) to allow the user the option of customizing where they want the audio to start and stop playing.
    g. Provide sufficient hard drive space on the data logging server to store 1000 hours of audio files to the security management server hard drive(s).

## PART 3 - EXECUTION

### 3.1 FIELD QUALITY CONTROL

A. Perform and document the following pass/fail tests:
    1. Verify field operation of every icon and button relating to the Electronic Security System GUI.

3.2 ADJUSTING

A. SSI shall provide basic adjustments to text, color, and representation of the facility at no additional charge during the final inspection of the project.

3.3 DEMONSTRATION

A. A Certified Systems Developer will perform the training at the Owner’s facility once the final inspection is complete.

B. Training shall be video recorded.

END OF SECTION 284620

# SECTION 284621.11 - ADDRESSABLE FIRE-ALARM SYSTEMS

## PART 1 - GENERAL

### 1.1 OVERVIEW

A. The fire alarm system is an addressable system. The VESDA system is extremely sensitive smoke detection system intended for use in locations as indicated on Electrical Construction Sheets. The VESDA system indicated has been selected for use in the inmate occupied pod cells and dayrooms; benefits of VESDA detection, in lieu of photoelectric smoke detectors, at these locations include:

a. Very early smoke detection of inmate normally occupied areas.

b. It minimizes disruptions to these large inmate housing areas for ongoing maintenance/testing/servicing and for code required periodic testing and certification of detectors using a code required smoke test.

1) The VESDA system allows for smoke tests to be performed remote from the VESDA smoke heads located in these inmate-occupied pod cells and dayrooms. This reduces logistical, security, and coordination efforts otherwise required by the Owner to facilitate a service technician with periodic testing and certification in the pods.
2) These pods, which house large numbers of inmates, cannot be easily shifted to other building spaces during smoke tests. Smoke testing in these spaces could be expected to extend over a 2 to 3-day period; further exasperating the planning and logistical efforts required by the Owner to facilitate smoke testing directly at smoke heads.

c. The VESDA smoke heads are a passive device and are less susceptible to costly vandalism within inmate occupied pod cells and dayrooms. In comparison, use of photoelectric smoke detectors in these areas requires a vandal-guard and more susceptibility to costly vandalism.

### 1.2 SUBSTITUTE REQUESTS

A. A substitute request, where approved by the Owner, Engineer, and AHJ, could be considered for use of VESDA detection in areas other than as indicated on Electrical Construction Sheets (i.e. - in lieu of the photoelectric smoke or heat detectors). Locations that may be considered may include:

1. Non-normally occupied inmate cells such as in Booking and Medical; i.e. where potential for vandalism would be more-costly to maintain the fire alarm detection system.
2. Areas where a higher smoke hazard could exist (i.e. Laundry) and very early detection would better-protect life, limb, or property.

B. Under no circumstance, during the bidding period, will a substitute request be initiated, considered, evaluated, or approved during the bid period. It would be the Contractor's responsibility to present and coordinate all necessary modifications and engineering efforts for such a substitute request.

1.3 RELATED DOCUMENTS

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

1.4 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Pre-action system.
3. Manual fire-alarm boxes.
4. System smoke detectors.
5. System Heat detectors.
6. Notification appliances.
7. Firefighters' smoke-control system.
8. Interactive Firefighter's Display.
9. Graphic annunciator workstation.
10. System printer.
11. Non-powered graphic annunciator panel.
12. Addressable interface device.
13. Network communications.
14. Remote fire alarm annunciators.
15. Remote status and alarm indicators
16. Addressable interface device.
17. Digital Telco Alarm Communicator Transmitter.
18. Digital Cellular Radio Alarm Communicator Transmitter.
19. Device guards.
20. Fire Alarm Cabling
21. VESDA Air-sampling smoke detectors.

B. Related Requirements:

1. Section 017823 "Operation and Maintenance Data."

2. Section 230993.11 "Sequence of Operations for HVAC DDC" for Firefighters' Smoke Control System and sequence of operation.

3. Section 260548.16 "Seismic Controls for Electrical Systems."

1.5 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. BMS: Building Management System.

C. FACP: Fire Alarm Control Panel.

D. HLI: High Level Interface.

E. LED: Light Emitting Diode.

F. LCD: Liquid Crystal Display.

G. NAC: Notification Appliance Circuit.

H. NICET: National Institute for Certification in Engineering Technologies.

I. PC: Personal computer.

J. VESDA: Very Early Smoke-Detection Apparatus.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Include network diagrams, field wiring diagrams, and detailed equipment wiring and termination diagrams.
5. Detail assembly and support requirements.
6. Include voltage drop calculations for notification-appliance circuits.
7. Include battery-size calculations.
8. Include input/output matrix.
9. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
10. Include performance parameters and installation details for each detector.

11. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
12. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
13. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by Firefighters' Smoke Control Station.
    c. Locate detectors according to manufacturer's written recommendations.
    d. Show air-sampling detector pipe routing.

C. General Submittal Requirements:

1. Submittals shall be approved by Authorities Having Jurisdiction prior to submitting them to Engineer.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level IV minimum.
    c. Licensed or certified by Authorities Having Jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

## 1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.8 Sample Warranty: For special warranty.

1.9 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to Authorities Having Jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.10 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamper-proofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
8. Filters for VESDA Air-Sampling Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
9. VESDA Air-Sampling Fan: Quantity equal to one (1) for every five (5) VESDA detectors, but no fewer than one (1) unit of each type.

1.11 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

1.12 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.13 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, the same system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Non-coded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

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

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Air-sampling smoke-detection system (VESDA).
6. Automatic sprinkler system water flow.
7. Pre-action system.
8. Fire-extinguishing system operation.
9. ANSUL
10. VESDA Air-Sampling Detectors

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
5. Activate smoke-control system (smoke management) at Firefighters' Smoke Control Station.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Activate pre-action system.
8. Activate emergency shutoffs for gas and fuel supplies.
9. Record events in the system memory.
10. Record events by the system printer.
11. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a pre-action sprinkler system.
3. Alert and Action signals of air-sampling detector system.
4. Independent fire-detection and -suppression systems.
5. User disabling of zones or individual devices.
6. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, and remote annunciators.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to the minimum requirements in ASCE 7-10 Chapter 13.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Seismic Requirements for Nonstructural Components:

a. Site Class: D.
b. Building Risk Category: III.
c. Seismic Design Category: C.
d. Component Importance Factor: 1.5.
e. Amplification Factors and Component Response Modification Factors: As required in ASCE 7-10 Table 13.6-1 (Mechanical and Electrical) for components and raceways and supports.

2.4 MANUFACTURERS (FIRE ALARM CONTROL UNITS, DEVICES, AND APPURTENANCES)

A. Manufacturer (Basis-of-Design): Owner has pre-approved the following manufacturer's system as the Basis-of-Design:

1. Gamewell, Security and Fire; a division of Honeywell.

2. This Owner pre-approved manufacturer shall be bid separately as an Alternate; refer to front end specifications for Alternate numbering and description.

a. Pricing for this manufacturer's system shall be listed separately in the Contractor's bid tab.

1) Bid tab shall break out pricing for this manufacturer's system separate from manufacturers; systems listed below.
2) Pricing for this manufacturer's system, shall be reviewed by the Owner and Engineer to determine if this Alternate is accepted in lieu of manufacturers' systems listed below which are submitted for approval as a performance equal and which are submitted for approval for pricing.

B. Manufacturers (Equals): Subject to compliance with requirements, products by one of the following manufacturers may be considered as an equal to the Basis-of-Design manufacturer listed above:

1. Edwards; UTC Climate, Controls & Security; a division of United Technologies Corporation.
2. Siemens Industry, Inc.; Fire Safety Division.

3. Either of these manufacturers' systems, if elected by Contractor for consideration for approval by Owner and Engineer, shall be 1) A performance equal to the Basis-of-Design manufacturer's system listed above and 2) Pricing shall be broken out separately by Contractor in the Bid Tab; separate from pricing for the Basis-of-Design manufacturer's system listed above.

C. Manufacturer shall have a minimum of three (3) independent factory authorized and trained service dealers/technicians, available within a fifty (50) mile radius of the installation, for ongoing and price competitive servicing of the installed system. Submit a listing of all qualified independent dealers/technicians within this radius capable of supporting the installed system.

2.5 FIRE-ALARM CONTROL UNIT (MAIN FIRE ALARM CONTROL PANEL FACP-1)

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
b. Include a real-time clock for time annotation of events on the event recorder and printer.
c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
d. The FACP shall be listed for connection to a central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Fire Alarm Control Unit to NAC Unit Communication:

1. Pathway Class Designations: NFPA 72, Class A, redundant pathway.
2. Pathway Survivability: Level 1.

D. Fire Alarm Control Unit to BMS Unit Communication:

1. Pathway Class Designations: NFPA 72, Class A, redundant pathway.
2. Pathway Survivability: Level 1.

E. Network Communication:

1. Pathway Class Designations: NFPA 72, Class C.
2. Pathway Survivability: Level 1.

F. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class E.
2. Pathway Survivability: Level 1.
3. Install no more than 50 addressable devices on each signaling-line circuit.

G. Serial Interfaces:
1. One dedicated RS 485 port for central-station operation using point ID DACT.
2. One dedicated RS 485 port for each of the following:

    a. Remote fire alarm annunciators (standard annunciators).
    b. Remote fire alarm annunciator (Interactive Fire Fighters' Display).
    c. Multi-interface module (printer port).

3. One USB port for PC configuration.

H. Gateway Interface to VESDA system

1. One RS 232 port for VESDA HLI communication interface (or gateway interface as required by VESDA).

I. Gateway Interface to Building Management System

1. BACnet port for BACnet communication interface to Building Management System.

J. Ethernet IP Gateways to “The Cloud”

1. Ethernet port for Ethernet IP Interface to “The Cloud” via VPN to Owner’s Intranet network.

a. Used for connection to “The Cloud” for manufacturer’s software solutions, manufacturer test and inspection, and manufacturer’s system manager app.

K. Smoke-Alarm Verification (Smoke detectors, Air-sampling smoke-detection system [VESDA]):

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

L. Smoke-Alarm Verification (Duct smoke detectors): Not required.

M. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

N. Door hold-open devices: Not applicable this project.

O. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status-and-sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out the final adjusted values on system printer.

P. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm receiving station.

Q. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

R. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, supervisory and digital telco alarm communicator transmitters, and digital cellular radio alarm communicator transmitter shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

S. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

T. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

## 2.6 PRE-ACTION SYSTEM

A. Initiate Pre-signal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a pre-action system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

## 2.7 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor, Detention Grade, Protective Shield (For inmate occupied areas as designated by an asterisk (‘*’) on the Electrical Construction Sheets): Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.8 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two (2) wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Multiple levels of detection sensitivity for each sensor.
    b. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Two (2) wire.
2. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
3. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

4. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
5. Each sensor shall have multiple levels of detection sensitivity.
6. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
7. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

D. Remote Test Station for Duct Smoke Detectors

1. Locations as indicated on Electrical Construction Sheets – i.e. Centrally located adjacent to Firefighters' Smoke Control Station.
2. Multi-colored LED Status Light: Light alternates between steady green (normal) and red (alarm).
3. Keyed test station. Provide minimum of two (2) spare keys.
4. Four (4) wire.

## 2.9 SYSTEM HEAT DETECTORS

A. Heat detector locations are as indicated on Electrical Construction Sheets. As part of the delegated design submittal, select rate of rise and fixed temperature based on performance requirements that are most appropriate for the area/location (i.e. to minimize detection response time for a flame or fire event).

B. Two (2) wire.

C. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

D. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (or as otherwise required by the delegated design) or a rate of rise that exceeds 15 deg F per minute (or as otherwise determined by the delegated design).

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

## 2.10 NOTIFICATION APPLIANCES

A. Non-addressable Notification Appliances shall be acceptable. Non-addressable notification appliances shall be connected to notification-appliance signal circuits and zoned as indicated on Electrical Construction Sheets. Appliances shall be equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red.

D. Master Sync: All visual notification devices throughout the building shall be synchronized strobes. Provide a master sync circuit at the fire alarm control panel and connect to the sync input of each NAC power supply.

## 2.11 FIREFIGHTERS' SMOKE-CONTROL SYSTEM

A. Smoke Control System, equipment, and components shall be supplied by HVAC/Mechanical Contractor. System and components shall comply with UL 864.

B. Fire alarm system shall communicate with the Building Management System (BMS) Panel via BACnet protocol or as otherwise required by the BMS Vendor.

1. The Fire Alarm Control Panel(s) shall be provided with a BACnet interface card. The fire alarm system Vendor shall coordinate with and provide to the BMS Vendor the address registers/descriptions at the Fire Alarm Control Panel(s) necessary for operation of the Smoke Control System.

2. The FACP Vendor shall demonstrate operation of the fire alarm/detection system in conjunction with demonstration of the Smoke Control System by the BMS Vendor. Demonstration shall be provided in the presence of the Owner, Engineer, and Authorities Having Jurisdiction.

C. Initiate Smoke-Management Sequence of Operation:

1. Comply with sequence of operation as described in Section 230993.11 "Sequence of Operations for HVAC DDC."
2. Fire-alarm system shall provide all interfaces and control points required to properly activate smoke-management systems.
3. First fire-alarm system initiating device to go into alarm condition shall activate the smoke-control functions.
4. Subsequent devices going into alarm condition shall have no effect on the smoke-control mode.

D. Addressable Relay Modules:

1. Provide address-setting means on the module. Store an internal identifying code for control panel use to identify the module type.
2. Allow the control panel to switch the relay contacts on command.
3. Have a minimum of two normally open and two normally closed contacts available for field wiring.
4. Listed for controlling HVAC fan motor controllers.

E. Comply with UL 864.

## 2.12 INTERACTIVE FIREFIGHTERS' DISPLAY

A. The remote annunciator panel in the Master Control Room shall be an interactive firefighters' display.

B. Features: 22" LCD Touch-Screen; recess mount or semi-recess mount.

C. The touch screen display will provide firefighters information about the building including:

1. A layout of building floor plans with room names and numbers.

2. Detailed site-specific information including:

a. Location of all supervised fire alarm devices.
b. Water supplies.
c. Evacuation routes.
d. Access Routes.
e. Chemical and structural hazards in the building.
f. Shutoffs for gas, power, and HVAC.

3. Status/Indication of Smoke Control equipment shall not be indicated at this display. Refer to Mechanical Specifications for requirements for status/indication/control at the Firefighters' Smoke Control Station.

## 2.13 GRAPHIC ANNUNCIATOR WORKSTATION

A. Provide a Graphic Annunciator Workstation for the fire alarm/detection system and the VESDA system. Workstation shall be located in the Facility Manager's Office as indicated on the Electrical Construction Sheets. Workstation shall include the following:

1. Workstation Software: PC-based, fire-alarm annunciator software with historical logging, report generation, and a graphic interface showing all alarm points in the system.

a. Provide support software such as:

1) System manager app.

a) Webserver for remote monitoring/troubleshooting/testing for remote users via system manager app.

2) Software for push notifications (text, email, etc.) to remote users.

b. VESDA software (i.e. Xtralis VSM) monitoring VESDAnet networking with annunciate alarms and faults through High Level Interface (HLI), shall reside on the PC.

c. Firmware upgrades.

2. Workstation Equipment: Provide PC with operating system software, hard drive with minimum storage as recommended by Vendor, two (2) large digital display monitors, wireless keyboard, wireless mouse, and other PC accessories for a complete and operable system. PC shall have minimum storage and processing power for Owner installed software such as MS Office. PC shall be configured with communication card for Ethernet IP Connection, PC network card for RS232 or RS485 connection to Fire Alarm Control Panel, RS232 to printer connection, and other network cards and communication ports as necessary or required by the Owner.

## 2.14 SYSTEM PRINTER

A. Printer shall be located at the Graphic Annunciator Workstation in the Facility Manager's Office as indicated on the Electrical Construction sheets.

B. Printer shall be listed and labeled as an integral part of fire-alarm system.

## 2.15 NON-POWER GRAPHIC ANNUNCIATOR PANEL

A. A non-powered/non-illuminated Graphic Annunciator Panel shall be located within Facility Office C1055 and mounted above the Fire Alarm Graphic Workstation as indicated on Electrical Construction Sheets. Graphic Annunciator Panel shall be used for the display of the building floor plan(s), room names/numbers, and fire alarm device types and locations.

B. Graphic Annunciator Panel: Mounted in an aluminum frame with nonglare, minimum 3/16-inch-thick, clear acrylic cover over graphic representation of the facility. Detector locations shall be represented by red LED lamps. Normal system operation shall be indicated by a lighted, green LED. Trouble and supervisory alarms shall be represented by an amber LED.

1. Surface mounted in a NEMA 250, Type 1 cabinet, with key lock and no exposed screws or hinges.
2. Graphic representation of the facility shall be a CAD drawing and each detector shall be represented in its actual location. CAD drawing shall be at 1/8-inch per foot scale or as otherwise required by Engineer to fit within the allotted wall space within the room and above the remote fire alarm annunciator panel.

## 2.16 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

C. Provide integration gateway using BACnet for connection to the Building Management System (BMS).

## 2.17 REMOTE FIRE ALARM ANNUNCIATORS

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush mount cabinet, NEMA 250, Type 1. Surface mount may be used where indicated on Construction Sheets and approved by Engineer.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

## 2.18 REMOTE STATUS AND ALARM INDICATORS

A. Description: Provide remote status and indicators with visual indication of an alarm on a concealed addressable detector.

B. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

## 2.19 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal equipment requiring shutdown or other functionality.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

## 2.20 DIGITAL TELCO ALARM COMMUNICATOR TRANSMITTER

A. A primary (Telco) Digital alarm communicator transmitter (DACT) shall be used as the primary transmission device. DACT shall be acceptable to the remote central station receiver and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two (s) POTS (Plain Old Telephone system) telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Power shall be provided from the fire alarm control panel battery/battery charger system.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to remote central station receiver.

## 2.21 DIGITAL CELLULAR RADIO ALARM COMMUNICATOR TRANSMITTER

A. A secondary (backup) alarm transmitter shall be provided for the fire alarm system. DACT shall be acceptable to the remote central station receiver and shall comply with UL 632.

B. Transmitter shall comply with:
1. NFPA 1221
2. 47 CFR 90
3. UL 864
4. UL 985

C. Description: Manufacturer's standard commercial product; factory assembled, wired, and tested; ready for installation and operation.

1. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
2. Signal Transmission Mode and Frequency: Cellular frequency coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
3. Normal Power Input: 120-V ac.
4. Secondary Power: Integral-sealed, rechargeable, 12-V battery and regulated battery charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.

5. Antenna: Provide directional or omnidirectional antenna. Where a remote, outdoor antenna is necessary, provide wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph with a gust factor of 1.3 without failure.
6. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
7. Antenna-Cable Connectors: Weatherproof.
8. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.

D. Functional Performance: Unit shall receive alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:

1. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
2. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
3. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
4. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
5. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
6. Local Fire-Alarm-System, Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm.

## 2.22 DEVICE GUARDS

A. Devices with detention rated guards are designated with an asterisk (‘*’) on Electrical Construction Sheets.

B. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

C. For visible notification units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

D. Guard for smoke detector shall be perforated and shall be UL tested and approved for use with the smoke detector. Refer to perforated smoke detector guard detail on Electrical Construction Detail Sheets.

2.23 FIRE ALARM CABLING

A. Performance Requirements

1. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

a. Flame-Spread Index: 25 or less.
b. Smoke-Developed Index: 50 or less.

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

B. UTP cabling.

C. Description: 100-ohm, four-pair UTP, covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
b. Communications, Riser Rated: Type CMR, complying with UL 1666.

D. RS-232 cabling.

1. Plenum-Rated Cable: NFPA 70, Type CMP.

a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
b. Plastic insulation.
c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
d. Plastic jacket.
e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
f. Flame Resistance: Comply with NFPA 262.

E. RS-485 cabling.

1. Plenum-Rated Cable: NFPA 70, Type CMP.

a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
b. Fluorinated ethylene propylene insulation.
c. Unshielded.
d. Fluorinated ethylene propylene jacket.
e. Flame Resistance: NFPA 262, Flame Test.

F. Low-voltage control cabling.

1. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

a. One pair, twisted, No. 16 AWG, stranded tinned copper conductors.
b. PVC insulation.
c. Unshielded.
d. PVC jacket.

2. Flame Resistance: Comply with NFPA 262

G. Control-circuit conductors.

1. Class 1 Control Circuits: Stranded copper, [Type THHN-THWN, complying with UL 83, in raceway].
2. Class 2 Control Circuits: Stranded copper, [Type THHN-THWN, complying with UL 83, in raceway].
3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

H. Fire alarm wire and cable.

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

a. Comtran Corporation.
b. Draka Cableteq USA.
c. Genesis Cable Products; Honeywell International, Inc.
d. Rockbestos-Suprenant Cable Corp.
e. West Penn Wire.

2. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
3. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG and/or size as recommended by fire alarm system manufacturer.
4. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.

5. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

    a. Line-Voltage Circuits: No. 12 AWG minimum.

2.24 VESDA AIR-SAMPLING SMOKE DETECTION (ASD) SYSTEM

A. General Description:

1. This VESDA system shall be installed in locations as indicated on Electrical Construction Sheets. This system is a point addressable, early warning fire detection system.
2. Air-sampling smoke detector shall be laser based using a piping system and a fan to transport the particles of combustion to the detector.
3. Provide two levels of alarm from each zone covered by the detector and two supervisory levels of alarm from each detector.
4. The air being sampled shall pass through filters to remove dust particulates greater than 20 microns before entering the detection chamber.
5. Detectors shall have the capability via RS 485 to connect up to 100 detectors in a network.
6. Detectors shall communicate with the fire-alarm control unit via addressable, monitored dry contact closures, RS 485, and interface modules. Provide a minimum of six relays, individually programmable remotely for any function.

B. Manufacturers: The manufacturer shall have a minimum of 35 years production experience in the design and manufacture of high sensitivity air sampling smoke detection systems. The manufacturer shall be certified as meeting ISO 9001:2008 for manufacturing. Subject to compliance with requirements, provide products by the following:

1. Xtralis; a division of Honeywell.
2. No approved performance equal.

C. Manufacturer shall have a minimum of three (3) independent factory authorized and trained service dealers/technicians, available within a fifty (50) mile radius of the installation, for ongoing and price competitive servicing of the installed system. Submit a listing of all qualified independent dealers/technicians within this radius capable of supporting the installed system.

D. Submittals -Submit the following for approval by Engineer:

1. Product Data
2. Shop drawings: Include equipment layout, wiring diagrams, labeling of devices and equipment, bills of material, mounting accessories/boxes/details, pipe layout, operational calculations and performance criteria.

    a. Pipe airflow balancing calculations shall be performed using approved calculation software. Design software tools such as ASPIRE may be used to generate this material.

3. Supplier Qualifications: The equipment supplier shall be authorized and trained by the manufacturer to calculate/design, install, test and maintain the ASD system based on code requirements. The equipment supplier shall submit a certificate of training from the manufacturer.
4. Installer Qualifications: The equipment installer shall be authorized and trained by the manufacturer and shall have the ability to install and test the ASD system. The installer shall submit a certificate of training from the manufacturer. The installation and programming of the ASD shall be completed by a factory-trained installer.
5. Calculations, design, and testing documents for review and approval by Engineer and Authorities Having Jurisdiction.
6. Operation and maintenance manuals.

E. Air Sampling Smoke Detectors [Monitoring/Alarming Panels] (Manufacturer: Xtralis; Model: VESDA-E VEA; Part Number: VEA-040-A10)

1. All tubing for each sample point shall be the same length based on its longest run and shall have a minimum of 100 feet as required me manufactures recommendation.

2. General Description:

    a. 40-point-addressable smoke detection points.

        1) Each detector shall not exceed a maximum of 40 sample points and shall not have less than 10 sample points per detector.

    b. Highly sensitive LASER-based smoke sensor module with replaceable filter.
    c. High capacity pump and a rotary valve connected to a network of individual microbore tubes with individual sampling points on microbore tubes.
    d. Modular
    e. LED and LCD User Interface:
    f. Optional relay module to annunciate individual alarms for the sampling points connected to the microbore tubes.
    g. VESDAnet networking to annunciate alarms and faults through High Level Interface (HLI) and / or on monitoring software such as VSM.

3. System Features:

    a. Approved to provide Early Warning Fire Detection (EWFD) / Class A / Class B and Standard Fire Detection (SFD) / Class C.
    b. Tested and approved to cover up to a 36,000 sq. ft. area subject to system design and local regulatory requirements.
    c. Consists of a highly sensitive LASER-based light scattering smoke sensor module, filter, rotary valve, pump, microbore tubes and sampling points.
    d. Consists of an air sampling microbore tube network with each tube having individual sampling point at the end to transport air to the detection system.
    e. Supports forty (40) point-addressable detection points with two individual smoke detection chambers each supporting 20 detection points.

f. Provide one (1) test port for each of the two (2) detection chambers to facilitate centralized and periodic code required smoke testing under user control of the forty (40) detection points.

4. General Requirements:

a. Housing: Smoke Sensor Module, Filter, Pump, Rotary valve and Relay Outputs shall be housed in a metal enclosure and shall be arranged in such a way that air is drawn from the fire risk area by the pump and a sample is passed through a sample filter and the smoke sensor module.
b. The detector shall have 40 microbore sampling tube inlets and must employ a flow measurement arrangement to detect individual flow per tube.
c. Light Source: The Detection Chamber shall employ a highly sensitive LASER light source and a photodiode.
d. Detection Method: The detection sensing method shall use a laser light source and at least one photodiode spaced inside the detection chamber to detect smoke particles. Smoke detection shall include:

1) Minimizing the effect of large dust particles on the true smoke obscuration.
2) Settable filter life based on the environment with notification when filter maintenance is required.

e. Absolute Calibration: The detection chamber shall be factory calibrated and shall not use adaptive algorithms or drift compensation techniques to adjust the sensitivity or detector output from that established during commissioning.
f. Filters: Disposable filter cartridge shall be capable of filtering particles in-excess-of 20 microns from the air sample. A second filter shall be ultrafine, removing more than 99% of contaminant particles of 0.3microns or larger, to provide a clean air barrier around the detector’s optics to prevent contamination and increased service life.

1) The filter shall be accessible by opening the cover to the field wiring terminal area. Once accessible, the filter shall be removable and replaceable using a readily available tool.

g. Pump: The pump shall be a capable of allowing for multiple microbore sampling tube runs up to 328 feet each with a transport time per applicable local codes.
h. Settable filter life based on the environment with notification when filter maintenance is required.
i. The detector shall have ability to perform leak test by isolating the external microbore tube network to ensure integrity of internal detection air path.
j. The detector shall employ modular construction allowing field replacement of the filter, smoke sensor module, rotary valve and the pump.

k. Provide:

1) Detection of sampling point and microbore tube blockage.
2) Detection of microbore tube breakage and sampling point presence at set intervals.
3) Cleaning of sampling point at set intervals

5. LED User Interface:

a. Include display module within each detector.
b. Each display shall provide the following features at a minimum:

1) A bar-graph display.
2) Four independent, high-intensity alarm indicators (ALERT, ACTION, FIRE-1, and FIRE-2), corresponding to the four alarm thresholds of the indicated sector.
3) Four (4) LED alarm threshold indicators to indicate ALERT, ACTION, FIRE-1 and FIRE-2 alarm events; one TROUBLE LED;
4) LED indication that the first alarm sector is established.
5) Detector fault and airflow fault indicators.
6) LED indicators shall be provided for faults originating in the particular zone (Zone Fault), faults produced by the overall smoke-detection system, and faults resulting from network wiring errors (Network Fault). Minor and urgent LED fault indicators.
7) Provide each of the 40-point addressable smoke detection points provided with a separate indicator LED.
8) Provide LED user interface with a button to support RESET and DISABLE commands; one DISABLE/STANDBY LED; and POWER ON/POWER OFF indication. All LEDs shall have appropriate symbols without any text.

6. LCD User Interface

a. Provide an LCD user interface option showing detector status for each of the 40-point addressable smoke detection points; including fault categories and smoke level relative to the fire alarm setting. Provide with the following characteristics:

1) Color LCD touch screen user interface with bar graph display.
2) Alarm threshold indicators for Alert, Action and Fire 1.
3) Fault icons indicating faults for these categories: detector, chamber, filter, flow, aspirator, network, power and external module where applicable.
4) A touch screen interface to allow scrolling through status screens on the LCD.

7. Monitoring and Alarming:

a. Supports five (5) addressable high-level-interface (HLI) alarms (i.e. general trouble, clean filter, tube blockage, and other field assignable as necessary).

b. Provide individual sampling point tube alarm (FIRE-1), identifying the fire location through addressable sampling point detection point by scanning the rotary valve, once global detector level fire alarm (FIRE-1) alarm is initiated.

c. Supports global detector level fire alarms during a smoke event with:

1) One (1) addressable output level identifying the fire location through addressable detection sampling points by scanning through the rotary valve.

2) Provide four (4) addressable output level alarm thresholds for the global detector alarm corresponding to ALERT, ACTION, FIRE-1, and FIRE-2.

a) Alarm Level 1 (ALERT): Activate a visual and an audible supervisory alarm. ALERT threshold set to a % of Fire-1 threshold

b) Alarm Level 2 (ACTION): Activate shutdown of electrical/HVAC equipment and activate a visual and an audible supervisory alarm. ACTION threshold set in the middle of ALERT and FIRE-1 thresholds

c) Alarm Level 3 (FIRE-1): Activate building alarm systems and initiate call to fire response unit. Global alarm FIRE-1 level shall be selectable from three options corresponding to sampling point sensitivity of High = 1.6% obs/m (0.5% obs/ft), Enhanced = 4% obs/m (1.3% obs/ft), and Standard = 8% obs/m (2.5% obs/ft).

d) Alarm Level 4 (FIRE-2): Activate suppression system or other countermeasures. Global alarm FIRE-2 alarm automatically set to two (2) times (2x) the global alarm (FIRE-1) setting.

e) The detector shall have two (2) adjustable pre-alarm smoke alarm thresholds:

f) Air-Sampling Flow Rates Outside Manufacturer's Specified Range: Result in a trouble alarm.

g) Provide software-programmable relays rated at 2 A at 30-V dc for alarm and fault conditions.

d. Supports High Level Interface (HLI) equipment for communication with the Main Fire Alarm Control Panel.

e. Detector shall also transmit the following faults:

1) DETECTOR
2) AIR FLOW
3) FILTER
4) SYSTEM
5) ZONE
6) NETWORK
7) POWER
8) CHAMBER
9) MODULE

f. Urgent and Minor Faults. Minor faults shall be designated as trouble alarms. Urgent faults, which indicate the unit may not be able to detect smoke, shall be designated as supervisory alarms
g. The detector shall support the generation and transmission of urgent and minor faults. Minor faults shall be considered as servicing or maintenance signals. Urgent faults indicate the unit may not be able to detect smoke.
h. The detector shall contain seven (7) or more relays for alarm and fault conditions. The relays shall be software programmable to the required functions. The relays shall be rated at 2 Amp at 30 VDC. Additional local relays shall be offered as an option to provide an alarm relay output for each of the microbore sampling tube representing a sampling point.
i. The detector shall have built-in event and smoke logging. It shall store smoke levels, alarm conditions, operator actions and faults. The date and time of each event shall be recorded. Each detector (zone) shall allow storage of up to 20,000 events and does not require the presence of a display in order to do so.
j. The detector shall incorporate a galvanically isolated General-Purpose-Input (GPI) which activates in the event of an applied voltage of 5 to 50VDC and can be assigned by configuration to activate one of several functions (Reset, Disable, Reset/Disable, Stand-by, Mains OK, Day/Night).
k. The detector shall incorporate a monitored voltage-free input, to be used with isolated relay contacts, which is supervised using a 10k Ohm terminating resistor.

8. Communication:

a. Report any fault on the detector by using configurable fault relay outputs.
b. Report any fault on the detector by using configurable fault relay outputs and/or via a peer-to-peer communications network. The Peer-to-Peer Communications Networking: A peer-to-peer networking facility shall be provided for the purposes of reporting alarms, faults and monitoring status, history and for configuration of devices. The peer-to-peer network shall:

1) Comprise a physical layer that shall:

a) Comply with the ANSI/TIA/EIA-485-A-1998 electrical specifications.
b) Employ asynchronous serial data transfer.
c) Operate at a baud rate no less than 19.2 kBaud.
d) Detect communications errors due to interference, open and short circuit.
e) Detect ground faults.

2) Support up to 200 devices (detectors, displays and programmers) of which 100 detectors can be supported.
3) Be configurable in a fault tolerant loop for short circuit, open circuit and ground fault. Any communication faults shall be reported unambiguously and shall be clearly attributable to an individual device or wire link in the fault messages.
4) Be configurable by PC based configuration tools that are available to configure and manage the network of detectors.

c. Secondary Communications

1) Detectors shall provide inbuilt secondary communications for monitoring and configuration using the following physical media:

a) USB.
b) 10/100 BaseT Ethernet.
c) WiFi (IEEE 802.11b/g).

d. Provide PC connection port at unit for laptop for programming, maintenance, service, and support.

9. Remote Monitoring from Remote PC Work Station

a. The VESDA system shall be integrated into the Fire Alarm/Detection System for monitoring of the overall building fire alarm/detection system.

1) Software: The VESDA system shall have available PC-hardware-based software to monitor all VESDA devices connected to a Peer-to-Peer VESDA system via High Level Interfaces.

2) Dedicated PC-based monitoring workstation.
a) Software for the Peer-to-Peer VESDA system shall be available to monitor all VESDA devices connected to the VESDA system; however, the software from the Fire Alarm/Detection Panel Manufacturer shall be utilized at this dedicated workstation for this project.
b) Work Station shall be located in the Facility Manager's Office as indicated on Electrical Construction Sheets.

b. VESDA Software Configuration and Programming

1) Configuration and programming may be performed using a Windows application such as Xtralis VSC running on a PC connected through a High-Level-Interfacing unit (PC-Link HLI) or by direct connection to a detector or through Ethernet network.
2) Configuration and programming tool shall support the following features at a minimum:

a) Programming of any device on the VESDAnet system as per the device documentation.
b) Viewing of the status of any device in the system.
c) Adjustment of the alarm thresholds of a nominated detector.
d) Setting of Day/Night, weekend and holiday sensitivity threshold settings.
e) Multi-level password control.
f) Programmable latching or non-latching relay operation.
g) Programmable energized or de-energized relays.

h) Programmable high and low flow settings for airflow supervision.
i) Number of microbore tubes in use and input maximum length of a microbore tube.
j) Programming if sampling points are used on a VEA detector.
k) Programmable maintenance intervals.
l) Facilities for referencing with time dilution compensation.
m) Testing of relays assigned to a specific zone to aid commissioning.

c. Security for WiFi Access

1) The following security measures shall be provided for secondary communications utilizing WiFi for a VESDA Peer-to-Peer system:

a) Connectivity via wireless access shall support WPA2 encryption with encryption key.
b) Access to a detector via Ethernet or WiFi shall be protected using a detector password specific to the detector and in addition to the WiFi encryption key.
c) All software connecting to a detector or peripheral shall support an authentication protocol to verify that it has been supplied by the manufacturer of the system.

d. Software Upgrades

1) There shall be provision for field upgrading the firmware in the system using a USB memory key connected directly to the detector, avoiding the need for a separate PC for this function.

F. Smoke detection sampling points (Non-Tamper Resistant)

1. Color: White
2. Mounting: Flush or surface mount as required.
3. The sampling points shall comply with the following requirements:

a. Sampling points shall not be separated by more than the maximum distance allowed for conventional point detectors as specified in the local codes and standards. Intervals may vary according to calculations. For AS1670.1-2004 the maximum allowable distance is 10.2m. For FIA the maximum allowable distance is 10.6m. For NFPA the maximum allowable distance is 30ft.
b. Each sampling point shall be identified in accordance with Codes or Standards.
c. Sample point shall have a built-in mechanism to enable sampling point testing and microbore tube integrity testing from the detector.

G. Smoke detection sampling points (Tamper Resistant)

1. Tamper-resistant, detention grade detection points shall be used for inmate occupied areas. These detection point locations are designated with an asterisk '*' on the Electrical Construction Sheets. Provide Torx-Center-Pin screws as specified in Specification Section 050553.

   a. Tamperproof detection points shall be stainless steel.
   b. Mounting options: Ceiling, Cabinet or open duct.
   c. Compatible with 6mm microbore tube.

2. The sampling points shall comply with the following requirements:

   a. Sampling points shall not be separated by more than the maximum distance allowed for conventional point detectors as specified in the local codes and standards. Intervals may vary according to calculations. For NFPA the maximum allowable distance is 30 feet.
   b. Each sampling point shall be identified in accordance with Codes or Standards.
   c. Sample point shall have a built-in mechanism to enable sampling point testing and microbore tube integrity testing from the detector.

H. High-Level-Interface (HLI) Units

1. Provide High-Level-Interface equipment at each VESDA smoke detector.

   a. HLI shall be capable of communicating directly with the Main Fire Alarm Control Panel for the following manufacturers:

      1) Notifier
      2) Edwards

   b. For other than the Main Fire Alarm Control Panel manufacturers listed above, provide a zone addressable module (ZAM) relay for monitoring of all alarms and status of detection points including:

      1) Each of the forty (40) point-addressable detection points and
      2) Each of the five (5) addressable high-level-interface (HLI) alarms and
      3) Each of the five (5) "global detector level fire" alarms.

I. Power Supply (Battery Charger and Batteries)

1. Each VESDA detector shall be powered from a Battery/Battery Charger Cabinet. Power shall be a regulated supply of nominally 24V DC. The 120VAC battery charger and 24VDC batteries shall comply with relevant Codes, Standards and Regulations.

   a. The VESDA detector shall be powered from a regulated supply of nominally 24V DC. The battery charger and batteries shall comply with the relevant Codes, Standards or Regulations.

      1) Battery backup shall provide 24 hours' standby, followed by 30 minutes in an alarm condition at maximum connected load.
      2) Primary Power: 24-V dc obtained from 120 VAC service.
      3) Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
      4) Batteries: Sealed lead calcium.

   b. Battery sizing calculations for the cabinet shall include the VESDA detector loads. Power supply shall comply with the following:

      1) UL 1481 Listed - Power supply and standby batteries shall be appropriately sized/rated to accommodate the system’s power requirements.

2. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

J. Microbore Sampling Tubes

1. The microbore sampling tube shall comply with the following requirements:

   a. Tubes used shall be 0.24” (6mm) OD / 0.16” (4mm) ID and 0.16” (4mm) OD / 0.1” (2.5mm) ID.
   b. Tubes shall have adequate markings to meet local codes and standards.
   c. Tubes shall be UL listed / recognized.
   d. Tubes shall be approved for use in the protected environment.

2. Where false ceilings are installed, the sampling tubes shall be installed above the ceiling, and sampling points shall be installed on the ceiling and connected to the sampling tube.
3. The sampling tubes shall be of the same length or use the manufacturer’s guidelines to run tubes of the required lengths using two diameter tubes 0.24” (6mm) and 0.16” (4mm) OD.

4. Maximum tube length shall be up to 328 feet (100m), however shorter tube lengths may be accommodated in accordance with the manufacturer’s guidelines.

    a. Extra tube lengths shall be neatly coiled and supported in a workmanlike manner. Locate coiling where readily accessible and to not obstruct working clearance.
    b. All tubing for each sample point shall be the same length based on its longest run and shall have a minimum length of 100 feet as required by manufacturer’s recommendations.

5. All joints in the sampling tubes must be air tight and made by using manufacturer recommended connectors.
6. Sampling tubes shall be installed in raceways and/or sleeves in the following areas:

    a. Above inaccessible ceilings.
    b. Finished areas.
    c. Areas subject to physical damage.
    d. Ceiling and/or wall penetrations.

7. Pipe Material: CPVC and complying with UL 1887, "Safety Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics."
8. Joints in the sampling pipe shall be airtight. Use solvent cement approved by the pipe manufacturer on all joints except at entry to the detector.
9. Identify piping with labels reading: "Aspirating Smoke Detector Pipe - Do Not Paint or Disturb" along its entire length at regular intervals according to NFPA 72.
10. Support pipes at not more than 60-inch centers.
11. Fit end of each trunk or branch pipe with an end cap and drilled with a hole appropriately sized to achieve the performance as specified and as calculated by the system design.

K. Sampling Holes:

1. Sampling holes of 5/64 inch, or other sized holes per manufacturer's written instructions, shall be separated by not more than the maximum distance allowable for conventional smoke detectors. Intervals may vary according to calculations.
2. Follow manufacturer's written recommendations to determine the number and spacing of sampling points and the distance from sampling points to ceiling or roof structure and to forced ventilation systems.
3. Each sampling point shall be identified by an applied decal.

L. Warranty

1. VESDA system and components shall comply with the warranty as indicated by Part 1 of this specification.

M. Spare Parts

1. Provide a list of recommended spare parts with the O&M manual. I.e. spare parts list for detector would include:

    a. Replaceable Pump.
    b. Replaceable Smoke Sensor Module/Chamber Assembly.
    c. Replaceable Rotary Valve.
    d. Replaceable LED Front Cover/LCD Front Cover

N. Installation

1. Contractor shall install the entire detection system in accordance with National and Local Codes and the Manufacturer's System Design Manual.

O. Testing, Demonstration, and Training

1. Commissioning Tests

    a. The VESDA Manufacturer’s Representative shall attend commissioning and demonstration of the entire installation in the presence of the Owner, Engineer, and Authorities Having Jurisdiction.
    b. All necessary instrumentation, equipment, materials and labor shall be provided by the Contractor.
    c. The Contractor shall record all tests and system configuration and a copy of these results shall be retained on site in the System Log Book.

2. System Check

    a. Visually check all microbore tubes to ensure that all tube joints, fittings, sampling points, etc. comply with this Specification.
    b. Check the system to ensure the following features are operational and programmed in accordance with the specification.

        1) Alarm threshold levels (for both day and night settings),
        2) Time delays,
        3) Number of tubes in use,
        4) Detector address,
        5) Display address where applicable,
        6) Clock time and date,
        7) Air flow fault thresholds,
        8) Reset button operable,
        9) Touch screen operable where applicable,
        10) Units set to United States standards.
        11) Check to ensure that all ancillary warning devices operate as specified.
        12) Check interconnection with Fire Alarm Control Panel to ensure correct operation.

c. Final Tests

1) The Contractor shall:

a) Introduce smoke into each detection chamber through the local test ports provided on the detector to ensure test ports are functional.
b) Verify that transport time from the sampling port connected to the longest microbore tube does not exceed the local code requirements using smoke signal rise on the VSC / VSM or the LCD display.
c) Activate the appropriate Fire Alarm zones and advise all concerned that the system is fully operational. Fill out the logbook and commissioning report accordingly.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

### 3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of Authorities Having Jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Equipment Mounting: Install fire-alarm control unit on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install seismic bracing. Comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above finished floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 60 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service to protect during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

M. Antenna for Digital Cellular Radio Alarm Communicator Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph wind load with a gust factor of 1.3 without damage.

## 3.3 PATHWAYS

A. Pathways shall be installed in EMT.

B. Exposed EMT shall be painted red enamel.

C. Boxes shall be painted red enamel.

## 3.4 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Data communication circuit(s) for connection to Building Management System (BMS) Panel for smoke management system.
2. Alarm-initiating connection to smoke-control system (smoke management) at Firefighters' Smoke-Control System Panel.
3. Alarm-initiating connection to Access System Control Panel.
4. Supervisory connections at standalone Fire Suppression Panels.

5. Supervisory connections at VESDA smoke detectors.
6. Supervisory connections at ANSUL.
7. Supervisory connections at valve supervisory switches.

## 3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

B. Install framed instructions in a location visible from fire-alarm control unit.

C. Identify system components, wiring, and cabling. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems

## 3.6 GROUNDING

A. For communications wiring, comply with J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

C. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

D. Ground shielded cables at the control panel location only. Insulate shield at device location.

## 3.7 CABLING INSTALLATION

A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.

1. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.

B. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

C. Comply with NECA 1.

D. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.

E. General Requirements for Cabling:

1. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlet and terminals.
2. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
3. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii.
4. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
5. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
6. Pulling Cable: Monitor cable pull tensions.

F. Fire Alarm Wiring Installation

1. Comply with NECA 1 and NFPA 72.
2. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."

    a. Install plenum cable in environmental air spaces, including plenum ceilings.
    b. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.

3. Wiring Method:

    a. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
    b. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
    c. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

4. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
5. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

6. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
7. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

G. Power and Control-Circuit Conductors

1. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
2. Minimum Conductor Sizes:

a. Class 1 remote-control and signal circuits, No. 14 AWG.
b. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
c. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

## 3.8 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

## 3.9 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Engineer and Authorities Having Jurisdiction.

B. Manufacturer's Field Service

1. Fire Alarm System - Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
2. VESDA System - Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative(s):

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative(s) shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections. Refer to Specification Section 014000 "Quality Requirements" for re-testing and re-inspecting requirements. Refer to Specification Section 017300 "Execution" for requirements for correcting the Work.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

## 3.10 FIELD QUALITY CONTROL - CABLING

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

1. Visually inspect UTP cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.11 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide maintenance service for twelve (12) month with skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

## 3.12 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two (2) years.

C. Firmware Service Upgrades: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: Provide at least thirty (30) days of advanced notice to the Owner to allow the Owner to schedule access to system and to upgrade computer equipment if necessary.

## 3.13 DEMONSTRATION AND TRAINING

A. Engage factory-authorized service representative(s) demonstrate the complete and operable system. Demonstration shall be coordinated with all other Vendors as necessary and shall include demonstration of all components including smoke control systems.

B. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Include training materials with Operation and Maintenance Manual. Training shall include a minimum of four (4) hours of field training and four (4) hours of classroom training for up to thirty (30) persons. Coordinate with Owner to determine classroom/conference room size and location and to determine the number of maintenance personnel that will attend.

C. Training shall include presentation, demonstration, and pricing to Owner for all the Manufacturer’s available software solutions for additional utilization features such as alarming (push notifications) to users at remote locations or monitoring/troubleshooting/testing by users at remote locations.

END OF SECTION 284621.11

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# SECTION 285123 – IP AUDIO COMMUNICATION SYSTEM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01, and Division 28 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the requirements for an IP audio communication system. The IP audio communication system shall be integrated with the overall Electronic Security System. The system shall be configured to support all intercom stations, speakers and touchscreen master modules shown on the security electronics plans.

B. The SSI shall provide an integrated IP audio communication system as specified herein. The system shall include all equipment, installation materials, set up, and testing to form a complete operating system. Independent system functions and integrated system functions to be fully verified as part of system testing and commissioning.

C. The Graphic User Interface (GUI) software (specified in section 284620) shall be the primary interface for the control and monitoring of the IP audio communication system (reference section 284620 for software functional requirements).

D. The SSI shall provide a digital interface between the PLC system and the Digital Communication Controllers for control by the PLC.

E. Digital Communication Controllers and Digital Communication Expanders shall be interconnected to form intercom exchanges. Each Digital Communication Controller (DCC) shall be capable of supporting up to four Digital Communication Expanders (DCEs). The SSI shall provide and install the required number of DCCs and DCEs to support the total number of intercom stations, ceiling speakers and touchscreen master modules in the system. All DCCs shall be connected to each other over a 10/100/1000Base-T network. This network shall provide data communications for the system. Reference section 282300 for network switch requirements.

F. The system shall include station audio level alarm detection (for ceiling speakers requiring this feature, as indicated on the plans) with adjustable detection settings for each individual station. SSI shall include with their bid the head-end equipment required to support this feature. The SSI shall adjust the audio level alarm detection settings for each station, with input from the Owner.

G. The SSI shall provide all hardware and software required to provide digital audio recording of the audio between all GUI stations and intercom stations and ceiling speakers with audio threshold detection.

H. The IP audio communication system shall include the following main components:

1. Digital Communication Controllers and Expanders

2. Administrator Software

3. Audio Master Stations

4. Intercom Stations & Loudspeakers

5. Accessories

1.3 DEFINITIONS

A. DCC: Digital Communication Controller

B. DCE: Digital Communication Expander

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies and indicate dimensions, loads, required clearances, components, and location of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For IP audio communication system to include in operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Schedules detailing locations, titles, and termination locations of all intercom stations, ceiling speakers and touchscreen master modules in the system.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

B. Intercom system equipment is to be designed and manufactured in accordance with ISO-9001 2000 Quality System Standard.

C. Manufacturer's quality control program to be registered in accordance with the above noted standard.

1.6 WARRANTY

A. Warranty Period: 12 months from date of Substantial Completion. The manufacturer shall repair or replace software and hardware that fails in materials or workmanship within specified warranty period.

1.7 EXTRA MATERIALS

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

1. Intercom Station: Furnish 1 spare intercom station of each type provided.

2. Touchscreen Master Module: Furnish 1 spare touchscreen master module.

PART 2 - PRODUCTS

2.1 DIGITAL COMMUNICATION CONTROLLERS

A. Manufacturer:

1. Harding Instrument Co. Ltd. - MicroComm DXL

B. Description: SSI shall provide required number of Digital Communication Controllers to form an intercom exchange capable of independent local operation. Each exchange capacity shall be increased as required by connecting additional Digital Communication Expanders (maximum of 4) to each DCC. The basis for the specification is Harding Instruments.

C. Digital Communication Controller (DCC):

1. Each DCC shall include the following:

a. Process Control Card (PCC)
b. Master Control Card (MCC)
c. Two Station Control Cards (SCC's)
d. Optional internal PCI card.
e. Front panel keypad/display for system setup and maintenance.
f. 110 VAC, 60 Hz power supply for internal functions.

D. Process Control Card (PCC):

1. Process Control Card shall contain system configuration and data, control exchange operations and switching, and provide exchange network ports.

2. PCC shall include the following:

a. USB network ports for exchange expansion.
b. Ethernet network ports for system expansion and external control by touch screen computers and graphic control panels.
c. Fiber optic or copper digital audio trunk ports.
d. Two serial ports.
e. Internal modem for transmitting and receiving data over a telephone line.

E. Master Control Card (MCC):

1. MCC shall include the following:

a. Include ports for any combination of two intercom or telephone set master stations.
b. Include two line-level audio inputs with status and control.
c. Include two line-level audio outputs with status and control.
d. Convert incoming audio signals to digital format and outgoing signals to analog format.
e. Intercom master station audio, press-to-talk and hook switch status transmitted over two single shielded pair cables with wiring supervision to detect open circuit and short circuit faults.
f. Telephone set master station functions all transmitted over a single wiring pair.

F. Station Control Card (SCC's):

1. SCC's shall include the following:

a. Each provides sixteen half-duplex intercom station ports which can be employed in adjacent pairs for full duplex devices.
b. Provide an interface for intercom stations. Units to convert incoming audio signals to digital format and outgoing signals to analog format. Each channel to monitor the status of up to two (2) switches associated with each intercom station.
c. Each card interfaces with 16 half-duplex channels. Each channel includes a separate audio power amplifier for non-blocking call operation and sixteen (16) independent software-controlled volume settings.
d. All station audio, switch, and power functions on 400 Series and 401 Series cards to be transmitted over a single shielded pair cable with supervision to detect open circuit and short circuit faults.
e. Audio and switch functions on 300 Series (Generic Intercom) station control cards to be transmitted on separate wiring pairs.

## 2.2 ADMINISTRATOR SOFTWARE

A. Manufacturer:

1. Harding Instrument Co. Ltd. - MicroComm DXL

B. Description: Administrator software shall be included with the IP audio communication system. SSI shall provide one licensed copy of the administrator software to the Owner at final completion. The basis for the specification is Harding Instruments.

C. Administrator Software:

1. Harding Instruments model DXL-SOF-ADM.
2. Administrator Software to function on a standard PC to support system configuration, diagnostics, maintenance, and logging but not be required for system operation.
3. Administrator Software to employ Windows features including views of system tree structure, tables of devices, screens for system settings and adjustments, and tables of operational data.
4. Configuration features to include:

    a. Creation of overall system architecture.
    b. Creation of multiple device templates.
    c. Copy and paste functions with auto-numbering and auto-assignment to create device schedules.
    d. Configuration error detection and alerts.
    e. Device naming and call routing functions.
    f. Device setting and performance functions.

5. Diagnostic and Maintenance features to include:

    a. Verification of system configuration and installation.
    b. Verification of system networks.
    c. Verification of device connections.
    d. Verification of system operation.
    e. Diagnostics via modem or Ethernet ports.

6. Logging features to include:

    a. Display of system activity with filtering options.
    b. Search by time and date.
    c. Search by device.
    d. Search by parameter.

7. SSI shall install a licensed copy of the Administrator software on the Security Management Server.

## 2.3 AUDIO MASTER STATIONS

A. Manufacturer:

1. Harding Instrument Co. Ltd. - MicroComm DXL

B. Description: VoIP Touchscreen Master Modules shall be provided to interface with the IP audio communication system. One VoIP touchscreen master module shall be provided at each GUI station location. The basis for the specification is Harding Instruments.

C. VoIP Touchscreen Master Module:

1. Harding Instruments model TMM-641-121-1.
2. The VoIP touchscreen master module shall include the following features:

a. Dimensions: 2.01” (H) x 5.35” (W) x 7.07” (D)
b. Operating Temperature: 32° to 122°F (0° to 50°C)
c. Humidity: 0 to 95% non-condensing
d. Field Connections: female RJ-45 connector
e. Power: 22.8Vdc – 37.8Vdc or EEE 802.3af compliant
f. Switch: 1 million operations
g. Speaker: 2.5” Mylar cone
h. Speaker level: 82 dB SPL max. @ 1 meter
i. Audio Output: 1V rms

## 2.4 INTERCOM STATIONS & LOUDSPEAKERS

A. Manufacturers:

1. Harding Instrument Co. Ltd. - MicroComm DXL
2. Quam-Nichols Co. (for loudspeaker only)
3. Lowell (for loudspeaker only)

B. Description: Intercom stations and loudspeakers shall be provided as shown on the plans. Intercom stations shall be the primary means of communication in the IP audio communication system between the GUI operator and the facility staff and offenders. All intercom stations shall include a call pushbutton switch. Ceiling speakers shown on the plans as designated with a “T” shall include audio threshold detection. The basis for the specification is Harding Instruments.

C. Intercom Stations:

1. Harding Instruments model ICE-420-217-000 for interior locations.
2. Harding Instruments model ICE-420-227-000 for exterior locations.
3. Harding Instruments model ICE-421-CUS-105 for interior locations with included “privacy switch” feature.
4. Harding Instruments model FDH-440-204-111 for interior stations with integrated handset.
5. Harding Instruments model ICE-620-227-000 for exterior site-located and bollard-mounted IP stations.
6. The intercom stations shall include the following features:

a. Intercom stations shall be designed for mounting on standard 2-gang outlet boxes. Faceplates shall be constructed of 11-gauge brushed stainless. Internal

steel offset grille to restrict inserting objects through speaker grille. Stations shall be ruggedly constructed and resistant to damage from soil and sprays.

b. Each intercom station shall incorporate an internal loudspeaker, microphone preamplifier and functioning multiplexing circuitry. One pushbutton shall be provided on each station. Pushbuttons shall be software assignable for placement of call requests or control of auxiliary functions.
c. Pushbuttons shall be single piece stainless steel construction and shall be backstopped to prevent excessive travel. Switch shall have positive tactile action with 1 million-operation lifetime.
d. Loudspeakers shall be waterproof Mylar cone type.
e. Stations shall be provided with MTA type insulation displacement connector that requires no wire stripping for installation.
f. Outdoor intercom stations shall be identical in all respects to standard intercom stations except that all metal plates and hardware shall be stainless steel, and internal circuitry and components shall be conformal coated.

D. Loudspeakers – Surface Mount:

1. Quam model SYSTEM 1VP, or equivalent by Lowell
2. The speaker assembly shall include the following components:

a. Loudspeaker: Quam model 8C5PAX
b. Transformer: Integral to unit, 5W, 25 and 70.7V, 5 taps
c. Enclosure: SE1WVP
d. Baffle: BS8W

3. The loudspeakers shall include the following audio features:

a. Average Sensitivity: 92 dB-SPL, 1W / 1M
b. Power rating: 12W-RMS, EIA 426A Standard
c. Calculated Output: 99dB-SPL, 5W/ 1M
d. Frequency Response: 65 Hz -17kHz EIA 426A Standard
e. Nominal Coverage Angle: 90° Included Angle, -6dB/2kHz, Half Space
f. Audio Connection: 7” long, color-coded tinned wires, pre-cut

E. Loudspeakers – Flush Mount:

1. Quam model SOLUTION 1, or equivalent by Lowell
2. The speaker assembly shall include the following components:

a. Loudspeaker: Quam model 8C10PAX
b. Transformer: Integral to unit, 5W, 25 and 70.7V, 5 taps
c. Back Box: ERD8U
d. Baffle: BR8WS
e. Mounting Device SSB-3

3. The loudspeakers shall include the following audio features:

a. Average Sensitivity: 95 dB-SPL, 1W / 1M
b. Power rating: 20W-RMS, EIA 426A Standard
c. Calculated Output: 102dB-SPL, 5W/ 1M
d. Frequency Response: 60 Hz -17kHz EIA 426A Standard
e. Nominal Coverage Angle: 90° Included Angle, -6dB/2kHz, Half Space
f. Audio Connection: 7” Color Coded Leads

2.5 ACCESSORIES

A. Manufacturer:

1. Harding Instrument Co. Ltd.

B. Quick Connect Boards and Interface Cables:

1. Harding Instruments model QCB-120-1 with model CBL-STN-XX-RR interface cable for audio.
2. Harding Instruments model QCB-120-2 with model CBL-SWT-XX-RR interface cable for switches.
3. The quick connect board shall include the following features:

a. Dimensions: 3.25” x 4.28” x 1.5”
b. Intercom station field connections: Screw clamp terminals
c. Exchange field connections: double ended cable

4. The SSI shall provide the required number of quick connect boards and interface cables for all intercom stations and ceiling speakers in the system.

C. Page Zone Expander:

1. Harding Instruments model PZE-110-0
2. The page zone expander shall include the following features:

a. Dimensions: 1.75” x 19” x 16.13”
b. General Features: Three relay-controlled paging inputs with six relay-controlled page outputs for each input. Screw terminal connections for both page inputs and outputs. Sixteen supervised input lines. Three status LEDs for “run”, “install” and “fault”.
c. Operating Temperature: 32 to 122° F
d. Storage Temperature: -40 to 158° F
e. Humidity: 0 to 95% non-condensing
f. Power Requirements: 95-135 VAC, 47-63 Hz, 150mA MAX
g. Paging Inputs: Maximum power; 100W max @ 25 Vrms per bank
h. Paging Outputs: Maximum power; 50W max @ 25 Vrms per channel
i. Standards: FCC Part 15, UL, CSA

3. The SSI shall provide the required number of PZE-110-0 units to support all paging zones as shown on the plans.

D. Intercom Pedestal:

1. The intercom pedestal shall include the following features:

a. Material: 12-gauge steel, powder-coated yellow
b. Minimum Dimensions: 72” (H) x 8” (W) x 8” (D)
c. Mounting: Designed to mount to flat pavement. Unit shall be secured to pavement with a minimum of 4 lag bolts.
d. Intercom Stations: Unit shall include two integral 2-gang back boxes for mounting two weatherproof intercom stations.
e. Site-located pedestals at gate locations shall include an additional 1-gang back box and a 2-gang back box for mounting a proximity reader and fixed dome camera.

EXECUTION

2.6 EXAMINATION

A. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances.

B. Comply with manufacturer’s installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

C. Precautions shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

2.7 INSTALLATION

A. Provide complete IP audio communication system as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All system equipment to be contained within equipment racks or cabinets.

D. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

E. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

F. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

G. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

H. Wires shall not be nicked, have strands removed, or have frayed strands when removing insulation or terminating.

I. Wiring shall be executed in strict adherence to standard broadcast practices.

J. All field device cables terminating to quick connector boards shall be labeled for easy identification.

## 2.8 CONNECTIONS

A. All IP audio communication system equipment connections shall be completed per manufacturer's recommendations and per SSI shop drawings.

B. Ground equipment according to manufacturer's recommendations.

## 2.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust IP audio communication system components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare pass/fail reports:

1. Intercom station inspection: SSI shall perform an inspection of each intercom station to ensure that each station pushbutton works correctly and that the volume of the speaker is adjusted to the optimum level.
2. Audio master stations shall be tested for proper operation.
3. Ceiling speakers with audio threshold detection shall be tested for proper operation.

C. Remove and replace malfunctioning units and retest as specified above.

## 2.10 ADJUSTING

A. SSI shall provide IP audio communication system configuration and adjustments. All intercom stations, loudspeakers and audio master stations shall be adjusted for optimum performance.

B. Occupancy Adjustments: Refer to specifications 280500, 3.5B.

2.11 DEMONSTRATION

A. Provide qualified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the IP audio communication system. Refer to Division 01 Section "Demonstration and Training."

B. Training shall be video recorded.

END OF SECTION 281500

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# SECTION 311000 - SITE CLEARING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
   1. Stripping and stockpiling topsoil.
   2. Removing above- and below-grade site improvements.
   3. Temporary erosion and sedimentation control.
   4. Clearing and grubbing.

B. Related Requirements:

   1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

### 1.3 DEFINITIONS

A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 5 percent organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; and free of weeds, roots, toxic materials, or other non-soil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.6 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or video recordings.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

B. Topsoil stripping and stockpiling program.

C. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.7 QUALITY ASSURANCE

A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

1.8 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place.

E. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

### 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls. Restore and stabilize areas disturbed during removal.

## 3.3 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Grind down stumps and remove roots larger than 2 inches in diameter, obstructions, and debris to a depth of 18 inches below exposed subgrade.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm) and compact each layer to a density equal to adjacent original ground.

## 3.4 TOPSOIL STRIPPING

A. Remove grass before stripping topsoil.

B. Strip topsoil to whatever depth encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and non-soil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 72 inches.
2. Do not stockpile topsoil within protection zones.
3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
4. Stockpile surplus topsoil to allow for re-spreading deeper topsoil.

## 3.5 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as necessary to facilitate new construction.

## 3.6 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Burning is prohibited.

C. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

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# SECTION 312000 - EARTH MOVING

## PART 1 - GENERAL

### 1.1 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Construction Manager. Authorized additional excavation and replacement material will be paid for according to Contract provisions changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Construction Manager. Unauthorized excavation, as well as remedial work directed by Construction Manager, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

## 1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct pre-excavation conference at Project site.

1. Review methods and procedures related to earthmoving, including, but not limited to, the following:

a. Personnel and equipment needed to make progress and avoid delays.
b. Coordination of Work with utility locator service.
c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
d. Extent of trenching by hand or with air spade.
e. Field quality control.
f. Ground improvement practices.

## 1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geotextiles.
2. Controlled low-strength material, including design mixture.
3. Warning tapes.
4. Engineered Fill

## 1.4 INFORMATIONAL SUBMITTALS

A. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.
2. Laboratory compaction curve according to ASTM D 698.

B. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

## 1.5 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.
1. To be provided by the Owner.

1.6 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Utility Locator Service: Notify 811-Call Before You Dig for area where Project is located before beginning earth-moving operations.

C. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 311000 "Site Clearing" are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of [washed] crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and zero to 5 percent passing a No. 8 sieve.

I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and zero to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C 33/C 33M; fine aggregate.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

## 2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   1. Survivability: As follows:
      a. Grab Tensile Strength: 157 lbf (700 N); ASTM D 4632.
      b. Sewn Seam Strength: 142 lbf (630 N); ASTM D 4632.
      c. Tear Strength: 56 lbf (250 N); ASTM D 4533.
      d. Puncture Strength: 56 lbf (250 N); ASTM D 4833.
   2. Apparent Opening Size: No. 70 (0.212-mm) sieve, maximum; ASTM D 4751.
   3. Permittivity: 0.1 per second, minimum; ASTM D 4491.
   4. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

## 2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting, flowable concrete material produced from the following:
   1. Portland Cement: ASTM C 150/C 150M, Type I/II.
   2. Fly Ash: ASTM C 618, Class C or F.
   3. Normal-Weight Aggregate: ASTM C 33/C 33M, 3/8-inch nominal maximum aggregate size.
   4. Water: ASTM C 94/C 94M.
   5. Air-Entraining Admixture: ASTM C 260/C 260M.

B. Produce conventional-weight, controlled low-strength material with 80-psi (550-kPa) compressive strength when tested according to ASTM C 495/C 495M.

2.4 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock,

soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

    a. 24 inches outside of concrete forms other than at footings.
    b. 12 inches outside of concrete forms at footings.
    c. 6 inches outside of minimum required dimensions of concrete cast against grade.
    d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    e. 6 inches beneath bottom of concrete slabs-on-grade.
    f. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe or 42 inches wide.

## 3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

## 3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

## 3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 6 inches each side of pipe or conduit.

C. Water and Conduits

1. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

a. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
b. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
d. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Storm and Sanitary Sewer

1. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.

a. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

## 3.8 SUBGRADE INSPECTION

A. Notify Construction Manager when excavations have reached required subgrade.

B. If Construction Manager determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction. Limit vehicle speed to 3 mph.
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Construction Manager, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Construction Manager, without additional compensation.

## 3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Construction Manager.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Construction Manager.

## 3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

## 3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, sub-drainage, damp proofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Removing concrete formwork.
4. Removing trash and debris.
5. Removing temporary shoring, bracing, and sheeting.
6. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

## 3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

D. Trenches under Roadways: Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete." Backfill voids with satisfactory soil while removing shoring and bracing.

E. Initial Backfill:

1. Soil Backfill: Place and compact initial backfill of subbase material or satisfactory soil, free of particles larger than 1 inch (25 mm) in any dimension, to a height of 12 inches (300 mm) over the pipe or conduit.

a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit.

F. Final Backfill:

1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.

G. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

## 3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations, and as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Use engineered soils for bioswales.
6. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

## 3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

## 3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:

1. Under structures, building slabs, and steps, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 100 percent.
2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.
3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. Under pavement, the upper 10 inches of subgrade shall be scarified and compacted to a dry density of at least 100-percent of the Standard Proctor maximum dry density (ASTM D-698). Any grade-raise fill placed within 1-ft of the base of the pavement section should also be compacted to at least 100 percent of the Standard Proctor maximum dry density. This can be reduced to 95-percent for engineered fill placed more than 1-ft below the base of the pavement section.

D. Locate and install ground improvement as indicated in ground improvement drawings and as directed by ground improvement specialty structural engineer.

## 3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

## 3.17 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Section 334600 "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.

## 3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:

1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place base course material over subbase course under hot-mix asphalt pavement.
3. Shape subbase course and base course to required crown elevations and cross-slope grades.
4. Place subbase course and base course 6 inches or less in compacted thickness in a single layer.
5. Place subbase course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698

C. Pavement Shoulders: Place shoulders along edges of subbase course and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil

materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

## 3.19 DRAINAGE COURSE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place drainage course 6 inches or less in compacted thickness in a single layer.
3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

## 3.20 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
2. Determine that fill material classification and maximum lift thickness comply with requirements.
3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Construction Manager.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:

1. At subgrade and at each compacted fill and backfill layer, at least one test for every 5000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

## 3.21 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Construction Manager; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

## 3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

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# SECTION 312319 - DEWATERING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes construction dewatering.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and dewatering system progress.
2. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Review condition of site to be dewatered including coordination with temporary erosion-control measures and temporary controls and protections.
3. Review geotechnical report.
4. Review proposed site clearing and excavations.
5. Review existing utilities and subsurface conditions.
6. Review observation and monitoring of dewatering system.

### 1.4 ACTION SUBMITTALS

A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.

4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in dewatering work.

1.7 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
2. The geotechnical report is referenced elsewhere in Project Manual.

B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.
2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
3. Prevent surface water from entering excavations by grading, dikes, or other means.
4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
5. Remove dewatering system when no longer required for construction.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Protect and maintain temporary erosion and sedimentation controls during dewatering operations.

### 3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

## 3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
3. Maintain piezometric water level a minimum of 24 inches below bottom of excavation.

C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

## 3.4 FIELD QUALITY CONTROL

A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water

from observation-well risers to demonstrate that observation wells are functioning properly.

3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

D. Prepare reports of observations.

## 3.5 PROTECTION

A. Protect and maintain dewatering system during dewatering operations.

B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION 312319

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# SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes temporary excavation support and protection systems.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
2. Section 312000 "Earth Moving" for excavating and backfilling, for controlling surface-water runoff and ponding, and for dewatering excavations.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review geotechnical report.
2. Review existing utilities and subsurface conditions.
3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
4. Review proposed excavations.
5. Review proposed equipment.
6. Review monitoring of excavation support and protection system.
7. Review coordination with waterproofing.
8. Review abandonment or removal of excavation support and protection system.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, performance properties, and dimensions of individual components and profiles, and calculations for excavation support and protection system.

B. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of soldier piles, piling, lagging, tiebacks, bracing, and other components of excavation support and protection system according to engineering design.
3. Indicate type and location of waterproofing.
4. Include a written plan for excavation support and protection, including sequence of construction of support and protection coordinated with progress of excavation.

C. Delegated-Design Submittal: For excavation support and protection systems, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Land surveyor.
2. Professional Engineer: Experience with providing delegated-design engineering services of the type indicated, including documentation that engineer is licensed in the state in which Project is located.

B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

## 1.6 CLOSEOUT SUBMITTALS

A. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

## 1.7 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility-serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Architect's written permission.

B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks, and record existing elevations.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design excavation support and protection systems to resist all lateral loading and surcharge, including but not limited to, retained soil, groundwater pressure, adjacent building loads, adjacent traffic loads, construction traffic loads, material stockpile loads, and seismic loads, based on the following:

1. Compliance with OSHA Standards and interpretations, 29 CFR 1926, Subpart P.
2. Compliance with AASHTO Standard Specification for Highway Bridges or AASHTO LRFD Bridge Design Specification, Customary U.S. Units.
3. Compliance with requirements of authorities having jurisdiction.
4. Compliance with utility company requirements.
5. Compliance with railroad requirements.

### 2.2 MATERIALS

A. Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A36/A36M, ASTM A690/A690M, or ASTM A992/A992M.

C. Steel Sheet Piling: ASTM A328/A328M, ASTM A572/A572M, or ASTM A690/A690M; with continuous interlocks.

1. Corners: Roll-formed corner shape with continuous interlock.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.

E. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.

F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

G. Reinforcing Bars: ASTM A615/A615M, Grade 60, deformed.

H. Tiebacks: Steel bars, ASTM A722/A722M.

I. Tiebacks: Steel strand, ASTM A416/A416M.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

3.2 INSTALLATION - GENERAL

A. Locate excavation support and protection systems clear of permanent construction, so that construction and finishing of other work is not impeded.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.

3.3 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation.

1. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement.
2. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging.
3. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds.

1. Trim excavation as required to install lagging.
2. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

## 3.4 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer.

1. Limit vertical offset of adjacent sheet piling to 60 inches.
2. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

## 3.5 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback, and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

## 3.6 BRACING

A. Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

## 3.7 MAINTENANCE

A. Monitor and maintain excavation support and protection system.

B. Prevent surface water from entering excavations by grading, dikes, or other means.

C. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

## 3.8 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open.

1. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions.
2. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

## 3.9 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures.

1. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.
2. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction, and abandon remainder.
3. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
4. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION 315000

# SECTION 316400 – STONE COLUMNS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

B. Section 311000 “Site Clearing” for temporary erosion and sedimentation control measures

C. Section 312000 “Earth Moving”

### 1.2 SUMMARY

A. Section includes ground improvement by installation of stone columns.
   1. Includes installation, monitoring, and testing of the stone columns.

### 1.3 REFERENCED STANDARDS

A. ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

B. ASTM D5778 Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils

### 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site or other location as agreed upon by all parties involved.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For stone columns, prepared by or under the supervision of a qualified professional engineer.

   1. Identify each column and indicate dimensions, cross sections, locations, and sizes.

C. Delegated Design Submittal: For stone columns, submit delegated design submittal for approval prior to beginning the Work covered in this section. Calculations shall be prepared by or under the supervision of a qualified professional engineer.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency, professional engineer, and installer.
   1. Professional engineer shall have errors and omissions design insurance for the work. The insurance policy shall provide a minimum coverage of $2 million per occurrence.

B. Stone column work schedule: include major milestones and date of completion.

C. Stone column QC/QA plan and procedures.

D. Daily Stone Column Progress Reports: furnish a complete and accurate record of stone column installation to the General Contractor. The record shall indicate the column location, length, average lift thickness and final elevations of the base and top of columns. The record shall also indicate the type and size of the densification equipment used. The Installer shall immediately report any unusual conditions encountered during installation to the General Contractor, to the Designer and to the Testing Agency.

1.7 CLOSEOUT SUBMITTALS

A. Record Drawings.

B. Certified Pile Survey: Submit within seven days of pile installation completion.

C. Report documenting the observations and results of the tests. This report shall certify that the indicated bearing pressure has been achieved within settlement tolerances.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1077, ASTM D 3740, and ASTM E 329 for testing indicated.

B. Installer Qualifications: Installer shall have a minimum of 5 continuous years of experience with projects of similar scope and complexity.
   1. Provide a list of at least five previously completed projects of similar scope and complexity. The list shall include a description of the project, relative size, and reference person with phone number

C. Professional Engineer Qualifications: Currently licensed in the Commonwealth of Kentucky and specializing in the design and detailing of stone columns.
   1. Provide a list of at least five previously completed projects of similar scope and complexity. The list shall include a description of the project, relative size, and reference person with phone number.

1.9 FIELD CONDITIONS

A. Protect structures, underground utilities, and other construction from damage caused by stone column excavation.

B. Site Information: A geotechnical report has been prepared for this Project and is referenced elsewhere in the Project Manual for information only.

C. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for auger cast grout piles. Before excavating, lay out each pile to lines and levels required. Record actual measurements of each pile's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.

1. Record and maintain information pertinent to each stone column and indicate on record Drawings. Cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design piles, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
1. Maximum allowable net bearing pressure for stone column reinforced soils = 4,000 psf.
2. Minimum stone column area coverage shall be as determined by the SSE.
3. Maximum long-term settlement <1 inch.
4. Maximum long-term differential settlement < 1/2 inch.
5. Design life of the structure shall be considered to be 50 years.

2.2 MATERIALS

A. Aggregate: Unless otherwise required by SSE, stone shall be used for stone columns. The backfill stone shall consist of relatively hard, angular to subangular durable rock fragments, with the size of particles in the range of $^{1}/_{8}$ inch to 1-½ inches. A gradation meeting the No. 57 (ASTM C33) criteria is acceptable.

B. Water: Potable water shall be used where water is required.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, and other hazards created by drilling operations.

B. Rough grade ground elevation at column locations to a minimum of 12 inches above required cutoff elevation.

3.2 EQUIPMENT

A. Vibrator: an electric Vibrator capable of providing at least 80 HP of rated energy and a centrifugal force of 15 tons. An appropriate metering device should be provided at such a location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the Vibrator. The vibrator shall be a minimum of 16 inches in diameter and be capable of creating stone columns with diameters as indicated.

3.3 EXCAVATION

A. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.

B. All Stone Column elements shall be pre-augered using mechanical drilling or excavation equipment. Installation of columns without pre-augering shall not be allowed.

C. If cave-ins occur during excavation such that the sidewalls of the hole are deemed to be unstable, steel casing or a drilling slurry shall be used to stabilize the excavation.

D. If cave-ins occur on top of a lift of aggregate such that the volume of the caved soils is greater than 10 percent of the volume of the aggregate in the lift, then the aggregate shall be considered contaminated and shall be removed and replaced with uncontaminated aggregate.

E. Drilling Tolerances:

1. Location: Pile centers maximum 6 inches from locations indicated.
2. Plumb: Within 2 percent from vertical.
3. Batter Angle: Within 4 percent from required angle.

3.4 INSTALLATION

A. Special high-energy impact densification apparatus shall be employed to densify the Aggregate Column elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate.

B. A minimum tamper CIMA energy level of 2,000 foot-pounds of force per minute shall be applied by the energy source.
C. The bottom of the excavation shall be densified prior to the placement of the aggregate. If wet, soft or sensitive soils are present, open-graded aggregate, such as ASTM No.57 stone or other, shall be placed at the bottom of the excavation and compacted to stabilize the element bottom and may serve as the initial lift.
D. Densification shall be performed using a beveled tamper. The beveled tamper foot is required to adequately increase the lateral earth pressure in the matrix soil during installation.
E. Downward pressure shall be applied to the tamper shaft during tamping.
F. Each lift of aggregate shall be tamped for a minimum time period as required by SSE.
G. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit corrective construction proposals to Architect for review before proceeding.

## 3.5 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Stone Column excavation, placement, and testing.

B. Modulus Test

1. A modulus test shall be performed to verify the parameter values selected for design. The modulus tests shall be of the type and installed in a manner specified herein.

a. A telltale shall be installed at the bottom of the test column so that bottom-of column deflections may be determined. Acceptable performance is indicated when the bottom of the column deflection is no more than 20% of the top of column deflection at the design stress level.
b. ASTM D1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, and load decrements.
c. With the exception of the load increment representing approximately 115% of the design maximum top of Stone Column stress, all load increments shall be held for a minimum of 15 minutes, a maximum of 1 hour, and until the rate of deflection reduces to 0.01 inch per hour, or less.
d. The load increment that represents approximately 115% of the design maximum stress on the Stone Column shall be held for a minimum of 15 minutes, a maximum of 4 hours and until the rate of deflection reduces to 0.01 inches per hour or less.
e. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.
f. Stone Column modulus testing shall be performed in accordance with the requirements outlined in the Design Submittal.
g. The location of the Stone Column modulus test should be coordinated with the project Geotechnical Engineer of record.

C. BOTTOM STABILIZATION VERIFICATION TEST

1. After completion of the bottom column bulb, or at any time during the process of constructing the column, the energy source may be turned off, and bottom stabilization verification test may be performed. These tests shall be performed when a new soil formation is encountered, or at the beginning of a project to provide quantitative information on column stabilization.
2. Bottom Stabilization Tests are performed by placing a reference bar over the cavity, marking the tamper shaft, applying energy to the tamper for an additional 15 seconds, and observing the downward deflection of the tamper shaft by observing the deflection of the mark on the tamper shaft.
3. Acceptable performance is indicated if the vertical movement of the shaft is less than 150% of the vertical movement measured for the modulus test column.
4. If the measured vertical movement exceeds 150% of the value achieved during the modulus test, added energy is applied to re-densify the bulb. The procedure for measure is then repeated. If there is still movement greater than 150% of that achieved during the modulus test and greater than ½ inch, a lift of loose aggregate may be placed on top of the compacted aggregate, and the verification test may be performed on this next lift after it is densified. If there is excessive movement on this lift, another lift may be placed and tested. Movement must be limited to below 150% of the values achieved for the modulus test before completion of 2/3 of the column depth.

D. DYNAMIC CONE PENETROMETER TEST

1. The Stone column elements shall be tested by the Dynamic Cone Penetrometer method (ASTM STP 399) at locations within the upper 1/3 of the column shaft length. The minimum acceptable criteria as an indicator of acceptable densification shall be at least 15 blows per 1-3/4 inch penetration.
2. Dynamic Cone Penetrometer testing shall be performed in each Stone column until such time as five consecutive tests indicate that the minimum criterion is met. Thereafter, such tests need not be performed on every column, provided that the aggregate used in the elements is representative of that previously tested. If average penetration resistances measured exceed 15 blows, and less than 10% of tests fall below 15 blows, then testing may be reduced to spot checks. A pattern of successful tests is sufficient to reduce testing to several tests per day.
3. Observation of questionable aggregate moisture content or questionable aggregate gradation appearance may determine the need for additional dynamic penetration testing to verify that the proper densification is being achieved.
4. Use of Dynamic Cone Penetrometer is not appropriate for use on open-graded aggregate such as No. 57 stone.

E. Pile Inspection Reports: Prepare inspection reports for each auger cast grout pile as follows:

1. Column location and identification as indicated on the Shop Drawing.
2. Column diameter.
3. Size and type of densification equipment used.
4. Actual top and bottom elevations.
5. Average lift thicknesses.

6. Final top centerline location and deviations from requirements.
7. Variation from plumb.
8. Date and time of starting and completing.
9. Automatic monitoring equipment record.
10. Testing results.
11. Remarks, unusual conditions encountered, and deviations from requirements.

F. Certified Stone Columns Survey: Prepared by a qualified land surveyor or professional engineer showing final location of columns in relation to the property survey and existing benchmarks.

1. Notify Architect when deviations from locations exceed allowable tolerances.

G. Stone Columns will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports.

## 3.6 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 316400

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# SECTION 321216 - ASPHALT PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
   1. Hot-mix asphalt patching.
   2. Hot-mix asphalt paving.

B. Related Requirements:

   1. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
   2. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.
   3. Section 321723 "Pavement Markings."

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

   1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

      a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
      b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Job-Mix Designs: For each job mix proposed for the Work.

1.5 INFORMATIONAL SUBMITTALS

A. Material Test Reports: For each paving material, by a qualified testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the current version of Standard Specifications of Indiana Department of Transportation (INDOT) for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
1. Tack Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
2. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.
3. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.6 deg C) at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: ASTM D 242/D 242M, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. All materials shall conform to applicable requirements of the current version of INDOT Standard Specifications Sections.

B. Tack Coat: rapid-curve liquid asphalt shall conform to applicable requirements of the current version of INDOT Standard Specifications Sections.

C. Water: Potable.

2.3 AUXILIARY MATERIALS

A. Sand: ASTM D 1073, Grade No. 2 or No. 3.

B. Joint Sealant: ASTM D 6690, Type II or III, hot-applied, single-component, polymer-modified bituminous sealant.

C. Pavement Marking Paint: Refer to specification 321723.

2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and complying with the following requirements:

1. Provide mixes per detail drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).

3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Testing Agency, and replace with compacted backfill or fill as directed.

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

## 3.2 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

C. Placing Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces. Install per detail drawing.

## 3.3 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at a minimum temperature of 250 deg F (121 deg C).
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches (25 to 38 mm) from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

## 3.4 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150 mm).
3. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

## 3.5 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent or greater than 100 percent.
2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

## 3.6 INSTALLATION TOLERANCES

A. Confirm installation tolerances do not result in exceeding acceptable slopes for accessibility. This includes, but is not limited to, all sidewalks and accessible portions of the parking lot. These areas shall not have a cross slope greater than 2%, nor running slope greater than 5%. Accessible parking and associated access aisle shall not have running or cross slopes greater than 2%. If any discrepancies are found, bring to the attention of Architect.

B. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus, or minus 1/2 inch (13 mm).
2. Surface Course: Plus 1/4 inch (6 mm), no minus.

C. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch (6 mm).
2. Surface Course: 1/8 inch (3 mm).
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

## 3.7 FIELD QUALITY CONTROL

A. Testing Agency: Construction Manager shall engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.

    a. One core sample will be taken for every 1000 sq. yd. (836 sq. m) or less of installed pavement, with no fewer than three cores taken.
    b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

E. Replace and compact hot-mix asphalt where core tests were taken.

F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

## 3.8 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan.

END OF SECTION 321216

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# SECTION 321313 - CONCRETE PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes Concrete Paving including the Following:

1. Driveways and Approaches.
2. Parking lots.
3. Curbs.
4. Walks.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
2. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
3. Section 321723 "Pavement Markings."
4. Section 321726 "Tactile Warning Surfacing" for detectable warning.

### 1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

### 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:

a. Concrete mixture design.
b. Quality control of concrete materials and concrete paving construction practices.

2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:

    a. Contractor's superintendent.
    b. Concrete paving Subcontractor.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.
9. Single Layer Bi-Axial Geogrid. Refer to Section 312000 Earthmoving.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field-Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

1.8 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and base just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet (30.5 m) or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from as-drawn steel wire into flat sheets.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

C. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars; assembled with clips.

D. Plain-Steel Wire: ASTM A 1064/A 1064M, as drawn.

E. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars. Cut bars true to length with ends square and free of burrs.

F. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

G. Hook Bolts: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.4 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C 150/C 150M, gray portland cement Type I.
2. Fly Ash: ASTM C 618, Class F.
3. Slag Cement: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1-1/2 inches for slabs over 6” thick. ¾ inches nominal elsewhere.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Air-Entraining Admixture: ASTM C 260.

D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain no more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.

## 2.5 FIBER REINFORCEMENT

A. Synthetic Fiber: Complying with ASTM C 1116/C 1116M, Type III.
1. Fibermesh 300 Synthetic Fiber
a. Application Rate: 1.5lb/CYD.

## 2.6 CURING MATERIALS

A. Concrete curing and sealing compound. A ready-to-use, acrylic curing and sealing compound for use on new and existing, interior and exterior, horizontal and vertical concrete surfaces. Product shall conform to: ASTM C 309, Type 1 Class A & B and ASTM C 1315 Type 1 Class A.

1. Euclid Chemical Company; Diamond Clear (or approved equal)

## 2.7 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.

B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Epoxy-Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:

1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

D. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch (3 to 6 mm).

## 2.8 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Slag Cement: 50 percent.
3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 5-1/2 percent plus or minus 1.5 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.
2. Air Content: 6 percent plus or minus 1.5 percent for 3/4-inch (19-mm) nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

F. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate and according to drawings.

G. Concrete Mixtures: Normal-weight concrete.

1. Compressive Strength (28 Days): 4000 psi (27.6 MPa)
2. Maximum W/C Ratio at Point of Placement: 0.45.
3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).

## 2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M [and ASTM C 1116/C 1116M]. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and base surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared base surface below concrete paving to identify soft pockets and areas of excess yielding.

1. Completely proof-roll base in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Correct base with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."

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

3.2 PREPARATION

A. Remove loose material from compacted base surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet (15.25 m)] unless otherwise indicated on drawings.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
4. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
5. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch (6-mm) radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

    a. Tolerance: Ensure that grooved joints are within 3 inches (75 mm) either way from centers of dowels.

2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) radius. Eliminate edging-tool marks on concrete surfaces.

## 3.5 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from base surface before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating dowels and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

## 3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

## 3.7 DETECTABLE WARNING INSTALLATION

A. Cast-in-Place Detectable Warning Tiles: Form blockouts in concrete for installation of tiles specified in Section 321726 "Tactile Warning Surfacing." Screed surface of concrete where tiles are to be installed to elevation, so that edges of installed tiles will be flush with surrounding concrete paving. Embed tiles in fresh concrete to comply with Section 321726 "Tactile Warning Surfacing" immediately after screeding concrete surface.

## 3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by curing compound as follows:

1. Curing Compound: Apply uniformly in continuous operation by power spray according to manufacturer's written instructions. Recoat al areas within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

## 3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 (ACI 117M) and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-feet- (3-m-) long; unleveled straightedge not to exceed 1/2 inch (13 mm).
4. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
5. Vertical Alignment of Dowels: 1/4 inch (6 mm).
6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.
7. Joint Spacing: 3 inches (75 mm).
8. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
9. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 5000 sq. ft. or fraction thereof of each concrete mixture placed each day.

a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231/C 231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

## 3.11 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

# SECTION 321373 - CONCRETE PAVING JOINT SEALANTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.

B. Related Requirements:

1. Section 321216 "Asphalt Paving" for constructing joints between concrete and asphalt pavement.

2. Section 321313 “Concrete Paving” for construction joints in concrete pavement.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of joint sealant and accessory.

### 1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Testing: Test joint sealants using a qualified testing agency.

1.7 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C).
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type SL.

2.3 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type II, or III.

2.4 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

2.5 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

### 3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

### 3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

## 3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

## 3.5 PAVING-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within concrete paving.

1. Joint Location:

    a. All joints in concrete paving.

2. Joint Sealant: Single-component, self-leveling, silicone joint sealant.
3. Joint-Sealant Color: As selected by Architect from Manufacturer’s full range.

B. Joint-Sealant Application: Joints between concrete and asphalt paving.

1. Joint Location:

    a. All joints between concrete and asphalt paving.

2. Joint Sealant: Hot-applied, single-component joint sealant.
3. Joint-Sealant Color: As selected by Architect from Manufacturer’s full range.

END OF SECTION 321373

# SECTION 321400 - UNIT PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
   1. Concrete pavers set on concrete.
   2. Cast-in-place concrete edge restraints.

B. Related Sections:
   1. Section 321313 "Concrete Paving" for concrete base under unit pavers and for cast-in-place concrete curbs serving as edge restraints for unit pavers.

### 1.3 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Pavers.
   2. Geotextiles

B. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.

C. Samples for Initial Selection: For the following: Each type of unit paver indicated.

D. Samples for Verification: Full-size units of each type of unit paver indicated.

### 1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

   1. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

C. Preinstallation Conference: Conduct conference at Project site.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained, and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

E. Store asphalt cement and other bituminous materials in tightly closed containers.

1.6 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS

2.1 CONCRETE PAVERS

A. Concrete Pavers: Solid paving units, made from normal-weight concrete with a compressive strength not less than 8000 psi water absorption not more than 5 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67. Pigment shall conform to ASTM C 979.

1. County Materials Corporation, Grand Milestone Paving Stones, Available through County Materials Corporation, Matt Bunch, phone 920 540-6210, or pre-approved equal.
2. Thickness: 2-3/4 inches .
3. Face Size and Shape: 12 by 18 inch rectangle.
4. Face Size and Shape: 12 by 24 inch rectangle.
5. Face Size and Shape: 12 by 12 inch square.
6. Color:As selected by Architect from manufacturer's full range.
7. Pattern: See plans

2.2 CURBS AND EDGE RESTRAINTS

A. Job-Built Concrete Edge Restraints: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 4000 psi.

2.3 SETTING-BED MATERIALS

A. Aggregates
1. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
2. Sand for Joints: Polymeric sand

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2, AASHTO M 288.
2. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.
3. Permittivity: 0.02 per second, minimum; ASTM D 4491.
4. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.

C. Drainage Geotextile: Nonwoven needle-punched geotextile fabric, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2, AASHTO M 288.
2. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D 4751.
3. Permittivity: 0.5 per second, minimum; ASTM D 4491.
4. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 PREPARATION

A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

C. Proof-roll prepared subgrade according to requirements in Section 31 20 00 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

D. Proceed with unit paver installation only after deficient concrete base has been corrected and are ready to receive leveling course for unit pavers.

## 3.3 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Pattern: See Plans

E. Tolerances: Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

F. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 92 00 "Joint Sealants."

G. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
   1. Install job-built concrete edge restraints to comply with requirements in Section 03 30 00 "Cast-in-Place Concrete."

## 3.4 CONCRETE PAVERS ON CONCRETE APPLICATION

A. Install concrete base according to Section 321313 "Concrete Paving".

B. Provide drainage notches in concrete base slab as indicated on Drawings. Fill voids with aggregate and affix drainage geotextile fabric over entire bed.

C. Place leveling course and screed to a thickness as indicated on Drawings, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.

D. Set pavers with a minimum joint width as indicated on Drawings, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size unit pavers.

1. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
2. Pavers to be placed along the edge shall be cut with a masonry saw.

E. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.

1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches (900 mm) of uncompacted pavers adjacent to temporary edges.
2. Before ending each day's work, compact installed concrete pavers except for 36-inch (900 mm) width of uncompacted pavers adjacent to temporary edges (laying faces).
3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches (90 mm) of laying face.
4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.

F. Fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add polymeric sand until joints are completely filled, then remove excess.

G. Do not allow traffic on installed pavers until sand has been vibrated into joints.

H. Repeat joint-filling process 30 days later.

## 3.5 REPAIRING AND CLEANING

A. As work progresses, remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

END OF SECTION 321400

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# SECTION 321713 - PARKING BUMPERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes wheel stops.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

## PART 2 - PRODUCTS

### 2.1 PARKING BUMPERS

A. Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete, 4000-psi minimum compressive strength, as shown on drawings. Provide chamfered corners, transverse drainage slots on underside, and a minimum of two factory-formed or drilled vertical holes through wheel stop for anchoring to substrate.

1. Surface Appearance: Free of pockets, sand streaks, honeycombs, and other obvious defects. Corners shall be uniform, straight, and sharp.
2. Mounting Hardware: as shown on drawings.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions.

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

3.2 INSTALLATION

A. General: Install wheel stops according to manufacturer's written instructions unless otherwise indicated.

B. Install wheel stops in bed of adhesive before anchoring.

C. Securely anchor wheel stops to pavement with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer. Recess head of hardware beneath top of wheel stop.

END OF SECTION 321713

# SECTION 321723 - PAVEMENT MARKINGS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

B. Related Requirements:
   1. Section 321216 "Asphalt Paving" for asphalt pavement.
   2. Section 321313 "Concrete Paving" for concrete pavement.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

   1. Review methods and procedures related to marking pavement including, but not limited to, the following:

      a. Pavement aging period before application of pavement markings.
      b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Include technical data and tested physical and performance properties.

### 1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the current Standard Specifications of Indiana Department of Transporation (INDOT) for pavement traffic markings.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature in accordance with INDOT Standard Specifications.

PART 2 - PRODUCTS

2.1 PAVEMENT-MARKING PAINT

A. Pavement Marking Paint: All pavement marking materials shall be in accordance with INDOT Standard Specifications for multi-component markings.

1. Color: White, Yellow, or Blue as indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.

B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for a minimum of 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).

1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond the stencil. Apply paint so that it cannot run beneath the stencil.

3.3 PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 321723

# SECTION 321726 - TACTILE WARNING SURFACING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Cast-in-place detectable warning tiles.

B. Related Requirements:

1. Section 321313 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Initial Selection: For each type of exposed finish requiring color selection.

C. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

### 1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

### 1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration of finishes beyond normal weathering and wear.
b. Separation or delamination of materials and components.

2. Warranty Period: Five years from date of Final Completion.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

B. Source Limitations: Obtain each type of tactile warning surfacing from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.

1. Color: As selected by Architect from manufacturer's full line.
2. Shapes and Sizes:
   a. As required, see drawings
3. Mounting:
   a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

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

3.2 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 321313 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.
2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 inch (3 mm) from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

3.4 CLEANING AND PROTECTION

A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 321726

# SECTION 323113.53 - HIGH-SECURITY CHAIN LINK FENCES AND GATES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. High-security chain-link fences and manual gates.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete equipment bases/pads for gate operators and controls and post footings.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Inspect and discuss electrical roughing-in, equipment bases, and other preparatory work specified elsewhere.
2. Review required testing, inspecting, and certifying procedures.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Fence and gate posts, rails, and fittings.
b. Chain-link fabric, reinforcements, and attachments.
c. Accessories: Barbed wire and Barbed tape.
d. Gates and hardware.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include accessories, hardware, gate operation, and operational clearances.

C. Samples for Initial Selection: For each type of factory-applied finish.

D. Samples for Verification: For each type of component with factory-applied finish.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Product Certificates: For each type of chain-link fence, operator, and gate.

C. Product Test Reports: For framework strength according to ASTM F1043, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Mockups: Build mockups to set quality standards for fabrication and installation.

1. Build mockup for typical chain-link fence and gate, including accessories.

a. Size: 20-foot length of fence.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.9 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace components of high-security chain-link fences and gates that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Failure to comply with performance requirements.
    b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
    c. Faulty operation of gate operators and controls.

2. Warranty Period: 15 years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in height measured between top and bottom of outer edge of selvage according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: One piece as indicated on Drawings.

    a. Steel Wire for Fabric: Wire diameter of 0.148 inch

        1) Mesh Size: 2 inches

2. Zinc-Coated Fabric: ASTM A392, Type II, Class 2, 2.0 oz./sq. ft. (610 g/sq. m)] with zinc coating applied after weaving.

3. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.
4. Selvage: Twisted and barbed top and bottom.

### 2.2 SECURITY FENCE FRAMEWORK

A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts.

1. Fence Height: As indicated on Drawings.
2. Heavy-Industrial-Strength Material: Group IA, round steel pipe, Schedule 40.

    a. Line Post: 2.875 inches in diameter.
    b. End, Corner, and Pull Posts: 4.0 inches in diameter.

3. Rail Members: Intermediate, top, bottom and brace rails according to ASTM F1043 for Heavy Industrial.

    a. Intermediate, top, bottom and brace rails: 1.66 inches in diameter.

4. Metallic Coating for Steel Framework:

    a. Type A: Not less than minimum 2.0-oz./sq. ft. (0.61-kg/sq. m) average zinc coating according to ASTM A123/A123M.

## 2.3 TENSION WIRE

A. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire according to ASTM A817 or ASTM A824, with the following metallic coating:

1. Type II: Zinc coated with Class 5 minimum coating weight of not less than 2.0 oz./sq. ft. (610 g/sq. m) of uncoated wire surface.

## 2.4 SWING GATES

A. General: ASTM F900 for gate posts and single swing gate types.

1. Gate Leaf Width: As indicated.
2. Framework Member Sizes and Strength: Based on gate fabric height as indicated.

B. Pipe and Tubing:

1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework.
2. Gate Posts: Round tubular steel.
3. Gate Frames and Bracing: Round tubular steel.

C. Frame Corner Construction: Welded.

D. Extended Gate Posts and Frame Members: Fabricate gate posts and frame end members to extend as indicated above top of chain-link fabric at both ends of gate frame as required to attach fence and barbed wire and tape assemblies.

E. Provisions for Electronic Detection System: Isolate gate from fencing to prevent transference of vibration. Gate hinge posts and latch posts may share the same footing but shall not be in contact with fence terminal posts.

1. Separation between Hinge and Latch Posts and Fence Termination Posts: 2 inches minimum, 2-1/2 inches maximum.

F. Hardware:

1. Hinges: 180-degree outward swing.
2. Automatic Deadlocking Electromechanical Gate Lock.

2.5 FITTINGS

A. Provide fittings according to ASTM F626.

B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive tension wire or top rail.

C. Rail and Brace Ends: For each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:

1. Top-Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches (152 mm) long.
2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails to posts.

E. Tension and Brace Bands, Tension Bars, and Truss Rod Assemblies: According to ASTM F2611.

F. Barbed Wire Arms: Pressed steel, with clips, slots, or other means for attaching strands of barbed wire, integral with post cap] for each post unless otherwise indicated, and as follows:

1. Provide line posts with arms that accommodate top rail or tension wire.
2. Provide corner arms at fence corner posts unless extended posts are indicated.
3. Single-Arm Type: Type I, slanted arm, Type II, vertical arm.
4. Double-Arm Type: Type III, V-shaped arm.
5. Use bolts or rivets for connection to posts.

G. Tie Wires, Clips, and Fasteners: According to ASTM F626.

1. High-Security Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:

a. Metallic-Coated Steel: 0.148-inch diameter wire; zinc coating.

H. Power-Driven Fabric Fasteners: As recommended in writing by manufacturer.

I. Finish:

1. Metallic Coating for Pressed Steel: Not less than 1.2 oz. /sq. ft. of zinc.

2.6 BARBED WIRE

A. Steel Barbed Wire: ASTM A121, High Security Grade, two-strand barbed wire; 0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round barbs spaced not more than 3 inches (76 mm) o.c.

1. Aluminum Coating: Type A.

## 2.7 BARBED TAPE

A. Wire-Reinforced Tape: ASTM F1910; continuous coil with four-point, needle-sharp barbs permanently cold clenched around a core wire.

1. Core Wire: High-tensile-strength, stainless steel.
2. Configuration: Single coil.
3. Style: Concertina pattern.
4. Coil Diameter: 18-inch.
5. Coil Loop Spacing: 12 inches.
6. Barb Length Classification: 2.5-inch barb.
7. Barb Spacing: 4 inches o.c.
8. Barb Set: Manufacturer's standard.

B. Clips: Stainless steel, 0.065 inch (1.65 mm) thick by 0.375 inch (9.5 mm) wide; capable of withstanding a minimum 150-lbf (667-N) pull load to limit extension of coil, resulting in a concertina pattern when deployed.

C. Tie Wires: Stainless steel, 0.065 inch (1.65 mm) in diameter.

## 2.8 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

## 2.9 GROUNDING MATERIALS

A. Comply with requirements in Section 260526 "Grounding and Bonding."

B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches (16 by 2440 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for earthwork, pavement work, and other conditions affecting performance of the Work.

1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

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

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 50 feet or line of sight between stakes. Indicate locations of utilities, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more, at any abrupt change in grade, and at intervals not greater than 500 feet (152 m). For runs exceeding 500 feet (152 m), space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 10 feet o.c.

F. Post Bracing and Intermediate Rails: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric. Install so posts are plumb when diagonal rod is under proper tension.

G. Barbed Wire Arms: Bolt or rivet to top of post. Angle single arms away from approach side of fence.

H. Top Rail: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

I. Bottom Rails: Secure to posts with fittings; anchor rail at midspan to concrete continuous grade beam.

J. Chain-Link Fabric: Apply fabric on the approach side of fence, inside of enclosing framework. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

1. Overlapping Fabric: Overlap ends of fence fabric at or between posts or rails; overlap 6 inches (152 mm) and secure with wire ties or steel strap method.
2. Buried Fabric: Where indicated, bury the bottom 12 inches of chain-link fabric in a vertical trench below the fencing; overlap above-grade fence fabric 6 inches (152 mm) and secure to bottom rail with tie wires. Backfill and compact trench before pouring concrete pavement.

K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches (380 mm) o.c.

L. Tie Wires: Power-fastened or manually fastened ties configured to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends one and one-half machine twists or three full manual twists and cut off protruding ends to preclude untwisting by hand.

1. Maximum Spacing: Tie fabric to line posts at 12 inches (305 mm) o.c. and to braces at 24 inches (610 mm) o.c.

M. Power-Fastening of Fabric: Fasten 0.148-inch wire fabric with 2-inch mesh size. Fasten fabric to line posts 12 inches (300 mm) o.c. and to braces 24 inches (610 mm) o.c.

N. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

O. Barbed Wire: Install barbed wire uniformly spaced, angled toward security side of fence. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

P. Barbed Tape: Install according to ASTM F1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.

## 3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

## 3.5 GROUNDING AND BONDING

A. Comply with requirements in Section 260526 "Grounding and Bonding."

B. Fence and Gate Grounding:

1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.
2. Install ground rods and connections at maximum intervals of 100 feet.
3. Ground fence on each side of gates and other fence openings.

    a. Bond metal gates to gate posts.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (152 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.

D. Connections:

1. Make connections with clean, bare metal at points of contact.
2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
4. Make above-grade ground connections with mechanical fasteners.
5. Make below-grade ground connections with exothermic welds.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

E. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor according to NFPA 780.

F. Comply with requirements in Section 264113 "Lightning Protection for Structures."

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: Construction Manager shall engage a qualified testing agency to perform tests.

B. Prepare test reports.

## 3.7 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

## 3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain high-security chain-link fences and gates.

END OF SECTION 323113.53

# SECTION 323119.53 - DECORATIVE METAL SECURITY FENCES AND GATES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Interior anti-climb steel security fences.
2. Swing gates.

B. Related Requirements:

1. Section 033000 - "Cast-in-Place Concrete" for concrete slab and post concrete fill.
2. Section 087163 – “Detention Door Hardware” for gate hardware.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fencing and gates.

1. Include plans, elevations, sections, gate locations, post spacing, mounting and attachment details.

C. Samples: For each fence material and for each color specified.

1. Provide Samples 12-inches in length for linear materials.

### 1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For gate operators to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. The contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.

PART 2 - PRODUCTS

2.1 ANTI-CLIMB SECURITY FENCES

A. System Description: The manufacturer shall supply a total commercial welded wire architectural fence system. The system shall include all components (i.e., panels, brackets, posts, gates and hardware) required.

B. Ant-Climb Security Fence:

a. Basis-of-Design Product. Subject to compliance with requirements, provide “WireWorks Anti-Climb” fence as manufactured by products by Ameristar Fence Products; an ASSA ABLOY Company or a comparable product.
b. Height: Refer to drawings.

2.2 MATERIAL

A. Steel material for fence posts and rails shall be galvanized prior to forming in accordance with the requirements of ASTM A653/A653M, with minimum yield strength of 45,000 psi (310 MPa). The steel shall be hot-dip galvanized to meet the requirements of ASTM A653/A653M with a minimum zinc coating weight of 0.90 oz/ft$^2$, Coating Designation G-90. Fence posts and gate posts shall meet the minimum size requirements of Table 1.

B. Steel wire mesh fence panels shall be welded by resistance welding per ASTM F2453 using pre-galvanized steel wire, welded at each crossing to form rectangles. Vertical 10.5ga. (0.128-inches) wires shall be spaced at 3 inches; horizontal 10.5ga. (0.128-inches) wires shall be spaced at .5 inches. The cold rolled wire shall have a tensile strength of at least 74,000 psi and 68,000 psi shear strength. Wire strand shall be galvanized before welded (GBW), .50 ounces per square foot zinc coating conforming to the ASTM A641.

C. The cross-sectional shape of the rails shall conform to the manufacturer's Impasse II™ C-rail design, a nominal 2” x 2” x 11 gage tamperproof fasteners shall be used to fasten each wire mesh retaining bracket to rail at intervals not exceeding 18-inches. Posts shall conform to the manufacturer's Impasse II™ I-Beam design with a nominal 3” x 2.75” x 12 gage up to 8-foot height, and 4” x 2.75” x 11 gage up to 10 foot height.

2.3 FABRICATION

A. Wire mesh panels and posts shall be precut to specified lengths. Panel width shall be no greater than 96" wide.

B. The manufactured fence system (i.e., panels, brackets, posts, gates and hardware) shall be subjected to the PermaCoat® thermal stratification coating process (high-temperature, in-line, multi-stage, multi-layer) including, as a minimum, a six-stage pretreatment/wash (with zinc phosphate), an electrostatic spray application of an epoxy base, and a separate electrostatic spray application of a polyester finish. The base coat shall be a thermosetting epoxy powder coating (gray in color) with a minimum thickness of 2 mils (0.0508mm). The topcoat shall be a "no-mar" TGIC polyester powder coat finish with a minimum thickness of 2 mils (0.0508mm). The stratification-coated framework shall be capable of meeting the performance requirements for each quality characteristic shown in Table 2.

C. Swing gates shall be fabricated using 2" x 12 gage square rails and gate ends. Gates that exceed 6' in width will have a 2" sq. x 12 gage intermediate upright. All rail and upright intersections shall be joined by welding. All rail, upright, and gate end intersections shall also be joined by welding. Steel gussets (1/4" x 2") shall be welded at each rail to gate end and rail to intermediate intersections. Gusset shall be punched to accept gate trussing cable and turnbuckle

PART 3 - EXECUTION

3.1 PREPARATION

A. All new installation shall be laid out by the contractor in accordance with the construction plans.

3.2 FENCE INSTALLATION

A. Fence post shall be spaced according to Table 3, plus or minus 1/4". Fence panels shall be attached to the line and end posts with fasteners supplied by the manufacturer. Attachment to corner post shall be made using brackets and fasteners supplied by the manufacturer (See Figure 1). Posts shall be set in concrete footers having a minimum depth of 36" (Note: Posts setting by other methods such as plated posts or grouted core-drilled footers are permissible only if shown by engineering analysis to be sufficient in strength for the intended application.

3.3 FENCE INSTALLATION MAINTENANCE

A. When cutting/drilling rails or posts adhere to the following steps to seal the exposed steel surfaces; 1) Remove all metal shavings from cut area. 2) Apply zinc-rich primer to thoroughly cover cut edge and/or drilled hole; let dry. 3) Apply 2 coats of custom finish paint matching fence color. Failure to seal exposed surfaces per steps 1-3 above will negate warranty. Ameristar spray cans or paint pens shall be used to prime and finish exposed surfaces; it is

recommended that paint pens be used to prevent overspray. Use of non-Ameristar parts or components will negate the manufactures' warranty.

3.4 GATE INSTALLATION

A. Gate posts shall be spaced according to the manufacturers' gate drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected. Type and quantity of gate hinges shall be based on the application; weight, height, and number of gate cycles. The manufacturers' gate drawings shall identify the necessary gate hardware required for the application. Gate hardware shall be provided by the manufacture of the gate and shall be installed per manufacturer's recommendations.

3.5 CLEANING

A. The contractor shall clean the jobsite of excess materials; post-hole excavations shall be scattered uniformly away from posts.

4 Table 1 – Minimum Sizes for WireWorks Anti-Climb Posts

| Fence Posts | Panel Height |
|---|---|
| 3" x 2.75" x 12 Ga. I-Beam | Up to & Including 8' Height |
| 4" x 2.75" x 11 Ga. I-Beam | Over 8' Height up to & including 10' Height |

| Gate Leaf | Gate Height | | | |
|---|---|---|---|---|
| | Up to & Including 6' | Over 6' Up to & Including 8' | Over 8' Up to & Including 10' | Over 12' |
| Up to 4' | 3" x 12Ga. | 3" x 12 Ga. | 4" x 11 Ga. | 4" x 11 Ga. |
| 4'1" to 6' | 3" x 12Ga. | 3" x 12 Ga. | 4" x 11 Ga. | 4" x 11 Ga. |
| 6'1" to 8' | 4" x 11 Ga. | 6" x 3/16" | 6" x 3/16" | 6" x 3/16" |
| 8'1" to 10' | 4" x 11 Ga. | 6" x 3/16" | 6" x 3/16" | 6" x 3/16" |
| 10'1" to 12' | 6" x 3/16" | 6" x 3/16" | 6" x 3/16" | 8" x 1/4" |
| 12'1" to 16' | 6" x 3/16" | 6" x 3/16" | 8" x 1/4" | 8" x 1/4" |

**Table 2 – Coating Performance Requirements**

| Quality Characteristics | ASTM Test Method | Performance Requirements |
|---|---|---|
| Adhesion | D3359 – Method B | Adhesion (Retention of Coating) over 90% of test area (Tape and knife test). |
| Corrosion Resistance | B117, D714 & D1654 | Corrosion Resistance over 3,500 hours (Scribed per D1654; failure mode is accumulation of 1/8" coating loss from scribe or medium #8 blisters). |

| | | |
|---|---|---|
| Impact Resistance | D2794 | Impact Resistance over 60 inch lb. (Forward impact using 0.625” ball). |
| Weathering Resistance | D822 D2244, D523 (60˚ Method) | Weathering Resistance over 1,000 hours (Failure mode is 60% loss of gloss or color variance of more than 3 delta-E color units). |

| **Table 3 – WireWorks Anti-Climb – Post Spacing** | |
|---|---|
| Span | 8’ Nominal (95” Rail) |
| | **Line & End Posts** |
| Post Size | 3” x 2.75” x 12 Ga. I-Beam or 4” x 2.75” x 11 Ga. I-Beam |
| Post Settings ± 1/4” O.C. | 96" |

END OF SECTION 323119.53

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# SECTION 32 91 13 - SOIL PREPARATION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes planting soils specified by composition of the mixes.

B. Related Requirements:
   1. Section 31 10 00 "Site Clearing" for topsoil stripping and stockpiling.
   2. Section 32 92 00 "Turf and Grasses" for placing planting soil for turf and grasses.
   3. Section 32 93 00 "Plants" for placing planting soil for plantings.

### 1.3 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended, or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

## 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include recommendations for application and use.
2. Include test data substantiating that products comply with requirements.
3. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site.

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Contractor shall engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil and imported soil.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.9 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by state-certified, -licensed, or -registered soil scientist under the direction of the testing agency.

1. Number and Location of Samples: Minimum of three representative soil samples from varied locations for each soil to be used or amended for landscaping purposes.
2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils."
3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.10 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:

1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":

    a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
    b. Hydrometer Method: Report percentages of sand, silt, and clay.

2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D 698 (Standard Proctor).

C. Chemical Testing:

1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of SSSA NAPT NCR-13, including the following:

1. Percentage of organic matter.
2. CEC, calcium percent of CEC, and magnesium percent of CEC.
3. Soil reaction (acidity/alkalinity pH value).
4. Buffered acidity or alkalinity.
5. Nitrogen ppm.
6. Phosphorous ppm.
7. Potassium ppm.
8. Manganese ppm.
9. Manganese-availability ppm.
10. Zinc ppm.
11. Zinc availability ppm.

12. Copper ppm.
13. Sodium ppm and sodium absorption ratio.
14. Soluble-salts ppm.
15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. for 6-inch depth of soil.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inchdepth of soil.

## 1.11 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 MATERIALS

2.2 PLANTING SOIL

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Planting-Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 4 percent organic matter content; free of stones 1 inch or larger in dimension and other extraneous materials harmful to plant growth.

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.
2. Form: Provide lime in form of ground dolomitic limestone.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C 33/C 33M.

2.4 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:

1. Feedstock: Limited to leaves.
2. Reaction: pH of 5.5 to 8.
3. Soluble-Salt Concentration: Less than 4 dS/m.

4. Moisture Content: 35 to 55 percent by weight.
5. Organic-Matter Content: 50 to 60 percent of dry weight.
6. Particle Size: Minimum of 98 percent passing through a 1-inchsieve.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

## 2.5 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

C. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

# PART 3 - EXECUTION

## 3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

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

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area to whatever depths encountered and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 2-inch sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 4 inches Remove stones larger than 1inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.

C. Mixing: Spread unamended soil to total depth of 4 inches, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

a. Mix lime with dry soil before mixing fertilizer if required.
b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 4 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.

C. Application: Spread planting soil to total depth of 4 inches but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Lifts: Apply planting soil in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.5 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of 8 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.

1. Mix lime with dry soil before mixing fertilizer if required.
2. Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: Construction Manager shall engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698. Space tests at no less than one for each 2000 sq. ft. of in-place soil or part thereof.

C. Soil will be considered defective if it does not pass tests.

D. Prepare test reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

## 3.7 PROTECTION

A. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

B. If planting soil or subgrade is over compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

3.8 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

END OF SECTION 32 91 13

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# SECTION 32 92 00 - TURF AND GRASSES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
   1. Hydroseeding for turf seed and native seed mixes.
   2. Erosion-control materials.

B. Related Requirements:

   1. Section 32 93 00 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
   2. Section 33 46 00 "Subdrainage" for below-grade drainage of landscaped areas.

### 1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

### 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

C. Product Certificates: For fertilizers, from manufacturer.

D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf seeding and native-mix seeding establishment.
   1. Experience: Five years' experience in turf and native-mix installation in addition to requirements in Section 01 40 00 "Quality Requirements."

   2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

   3. Pesticide Applicator: State licensed, commercial.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Bulk Materials:

   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

1.8 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

1. Turf Seeding:

    a. Spring Planting: April 15 – May 15
    b. Fall Planting: Aug. 15 – Sept. 15

2. Native Mix Seeding

    a. Spring Planting: April 15 – June 15
    b. Fall Planting: Oct. 1 – Nov. 30

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

## PART 2 - PRODUCTS

### 2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:
1. Quality: Seed of grass species as listed below for solar exposure, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed.

2. Native seed mixes:

| **Native Seed Mix 1** | | |
|---|---|---|
| | | **Pure Live Seed (PLS)** |
| **Botanical Name** | **Common Name** | **Ounces/Acre** |
| **Permanent Grasses:** | | |
| *Bouteloua curtipendula* | Side-Oats Grama | 36.00 |
| *Carex spp.* | Prairie Sedge Species | 8.00 |
| *Elymus canadensis* | Canada Wild Rye | 36.00 |
| *Elymus virginicus* | Virginia Wild Rye | 36.00 |
| *Schizachyrium scoparium* | Little Bluestem | 42.00 |
| *Sorghastrum nutans* | Indian Grass | 42.00 |
| | **Total** | **200.00** |
| **Temporary Cover:** | | |
| *Avena sativa* | Common Oat | 512.00 |
| *Lolium multiflorum* | Annual Rye | 240.00 |
| | **Total** | **752.00** |

| Native Seed Mix 2 | | |
|---|---|---|
| | | Pure Live Seed (PLS) |
| **Botanical Name** | **Common Name** | **Ounces/Acre** |
| **Permanent Grasses:** | | |
| *Bouteloua curtipendula* | Side-Oats Grama | 30.00 |
| *Carex spp.* | Prairie Sedge Species | 5.00 |
| *Elymus canadensis* | Canada Wild Rye | 36.00 |
| *Elymus virginicus* | Virginia Wild Rye | 36.00 |
| *Schizachyrium scoparium* | Little Bluestem | 42.00 |
| *Sorghastrum nutans* | Indian Grass | 36.00 |
| | **Total** | **185.00** |
| **Temporary Cover:** | | |
| *Avena sativa* | Common Oat | 480.00 |
| *Lolium multiflorum* | Annual Rye | 205.00 |
| | **Total** | **685.00** |
| **Forbs:** | | |
| *Asclepias tuberosa* | Butterfly Weed | 8.00 |
| *Coreopsis lanceolata* | Sand Coreopsis | 5.00 |
| *Echinacea purpurea* | Broad-Leaved Purple Coneflower | 8.00 |
| *Lupinus perennis v. occidentalis* | Wild Lupine | 4.00 |
| *Rudbeckia hirta* | Black-Eyed Susan | 5.00 |
| | **Total** | **30.00** |

3. Native seed mix rate:

    a. Apply Native Seed Mixes 1 and 2 at 60 PLS pounds per acre.

4. Turf seed mix: Proportioned by weight as follows:
    a. 90 percent (90%) Turf Type Tall Fescue (Festuca arundinaceous). Minimum 3 cultivars.
    b. 10 percent (10%) Kentucky bluegrass (Poa pratensis).

2.2 FERTILIZERS

A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
    1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.3 MULCHES

A. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

B. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

C. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.4 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.5 EROSION-CONTROL MATERIALS

A. Erosion-Control as shown on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
3. Uniformly moisten excessively dry soil that is not workable, or which is dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

## 3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

## 3.3 TURF AND NATIVE SEEDING AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 13 "Soil Preparation."

B. Placing Planting Soil: Place manufactured planting soil over exposed subgrade.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

## 3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf and Native Seeding Area Preparation" Article.

B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

## 3.5 HYDROSEEDING

A. Hydroseeding: Mix specified seed, slow-release fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
2. Spray-apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

## 3.6 TURF AND NATIVE SEEDING MAINTENANCE

A. General: Maintain and establish turf and native seeding areas by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth area. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and native seeding areas and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf seeded areas (only) as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
1. Mow specified turf to a height of 2-1/2 to 3 inches.

D. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.7 SATISFACTORY TURF SEEDED AND NATIVE SEEDED AREAS

A. Seeded installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf and Native Mixes: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10-sq. ft. and bare spots not exceeding 5 by 5 inches.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.8 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.9 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

3.10 MAINTENANCE SERVICE

A. Turf and Native Seed Mixes Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf and Native Mix Seeded Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. 60 days from date of Substantial Completion.
   a. When initial maintenance period has not elapsed before end of planting season, or if turf or native mix areas are not fully established, continue maintenance during next planting season.

END OF SECTION 32 92 00

# SECTION 32 93 00 - PLANTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Plants.
2. Tree stabilization.
3. Landscape edgings.

B. Related Requirements:
1. Section 32 92 00 "Turf and Grasses" for turf (lawn), hydroseeding, and erosion-control materials.

### 1.3 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than sizes indicated wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag.

Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation" for planting soils.

L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

## 1.4 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

## 1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

## 1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.

B. Samples for Verification: For each of the following:

1. Shredded Hardwood Mulch: 1 gal. in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on-site; provide an accurate indication of color, texture, and makeup of the material.

## 1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

## 1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

## 1.9 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Architect of sources of planting materials seven days in advance of delivery to site.

## 1.10 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. Apply antidesiccants to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccants at nursery before moving and again two weeks after planting.

F. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

G. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.
4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

## 1.11 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 15 -June 1
2. Fall Planting: August 15 - November 1

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

## 1.12 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
b. Structural failures including plantings falling or blowing over.
c. Faulty performance of tree stabilization or edgings.

d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods: From date of Substantial Completion.

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.

3. Include the following remedial actions as a minimum:

a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

## PART 2 - PRODUCTS

### 2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including

genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

## 2.2 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Shredded hardwood
2. Size Range: 3 inches maximum, 1/2 inch minimum.
3. Color: Natural.

## 2.3 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

## 2.4 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.5 TREE-STABILIZATION MATERIALS

A. Basis of Design: Below Grade Tree Staple stabilizers as manufactured by Tree Staple, Inc. or approved equal.

1. Materials: Uncoated, cold-rolled plain carbon steel which will dissipate in soil over time.

2. Model: TS24; 24 inches.
   a. Tree Caliper: 1 inch – 2 inches
   b. Number of Tree Staples Per Tree: 2 with up to a 16-inch diameter root ball.

3. Model: TS36; 36 inches.
    a. Tree Caliper: 2 inches – 4 inches
    b. Number of Tree Staples Per Tree: 2 with up to a 24-inch diameter root ball.

## 2.6 LANDSCAPE EDGINGS

A. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
1. Edging Size: 1/4-inch-thick by 5 inches deep.
2. Stakes: Tapered steel, a minimum of 16 inches long.
3. Accessories: Standard tapered ends, corners, and splicers.
4. Finish: Manufacturer's standard paint.

    a. Paint Color: Black

## 2.7 MISCELLANEOUS PRODUCTS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

B. Burlap: Non-synthetic, biodegradable.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable, or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

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

## 3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Install subdrainage in planting beds as shown on drawings. Connect to storm system.

D. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

E. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

## 3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 13 "Soil Preparation."

A. Placing Planting Soil: Place and mix planting soil according to Section 32 91 13 "Soil Preparation."

B. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

## 3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter for balled and burlapped and container-grown stock.
3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
4. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.

5. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
6. Maintain supervision of excavations during working hours.
7. Keep excavations covered or otherwise protected when unattended by Installer's personnel.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

## 3.5 TREE, SHRUB, AND GROUNDCOVER PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare2 inches above adjacent finish grades.

1. Backfill: Planting soil for trees, use excavated soil for backfill.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

4. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.

1. Backfill: Planting soil for trees, use excavated soil for backfill.

2. Carefully remove root ball from container without damaging root ball or plant.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

4. Continue backfilling process. Water again after placing and tamping final layer of soil.

## 3.6 TREE STABILIZATION

A. Below Grade Tree Staple stabilizers: Install per manufacturers written directions on all evergreen and deciduous trees.

## 3.7 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

## 3.8 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches and secure seams with galvanized pins.
   1. Do not install weed barrier fabric in bioswale area.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

   1. Trees in Turf Areas: Apply organic mulch ring of 3-inch average thickness, with 36-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.

2. Shredded Hardwood Mulch in Planting Areas: Apply 4-inch average thickness of mulch over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

## 3.9 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

## 3.10 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

## 3.11 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
1. Species of Replacement Trees: Same species being replaced.

## 3.12 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.13 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

1. Maintenance Period: Three months from date of Substantial Completion.

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

1. Maintenance Period: Three months from date of Substantial Completion.

END OF SECTION 32 93 00

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# SECTION 334100 - STORM UTILITY DRAINAGE PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Cleanouts.
3. Manholes.
4. Catch basins.
5. Stormwater inlets.
6. Dry wells.
7. Inline Basin.

### 1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

### 1.4 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Manholes: Include plans, elevations, sections, details, frames, and covers.
2. Catch basins, inlets, and dry wells. Include plans, elevations, sections, details, frames, covers, and grates.

### 1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

D. Handle catch basins, inlets, and dry wells according to manufacturer's written rigging instructions.

## PART 2 - PRODUCTS

### 2.1 PE PIPE AND FITTINGS

A. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10: AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.

B. Corrugated PE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

### 2.2 PVC PIPE AND FITTINGS

A. PVC Cellular-Core Piping:

1. PVC Cellular-Core Pipe and Fittings: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
2. Fittings: ASTM D 3034, SDR 35, PVC socket-type fittings.

B. PVC Profile Sewer Piping:

1. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

C. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D 3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

D. PVC Gravity Sewer Piping:

1. Pipe and Fittings: ASTM F 679, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.

## 2.3 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76.

1. Bell-and-spigot ends and gasketed joints with ASTM C 443, rubber gaskets
2. Class III.

## 2.4 CLEANOUTS

A. Cast-Iron Cleanouts:
1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
2. Top-Loading Classification(s): Heavy Duty.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

## 2.5 MANHOLES

A. Standard Precast Concrete Manholes:

1. Manholes shall be provided as detailed on the Plans.

B. Manhole Frames and Covers:

1. Frames and covers shall be Neenah R-1714 or approved equal.

## 2.6 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

2. Benches: Concrete, sloped to drain into channel.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

## 2.7 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

1. Catch basins shall be provided as detailed on the plans.

B. Frames and Grates:

1. Frames and grates shall be Neenah R-3287-10V or approved equal.

## 2.8 STORMWATER INLETS

A. Stormwater Inlets:

1. Stormwater inlets shall be provided as detailed on the plans.

B. Frames and Grates:

1. Type J and M Inlets.

a. Frames and grates shall be Neenah R-3287-10V or approved equal.

2. Type A Inlets.

a. Frames and grates shall be Neenah R-3472 or approved equal.

## 2.9 DRY WELLS

A. Dry Wells:

1. Dry wells shall be provided as detailed on the plans.

B. Frames and grates:

1. In grass, frames and grates shall be Neenah R-2561-A or approved equal, except as noted below.

2. In pavement, frames and grates shall be Neenah R-2390 or approved equal, except as noted below.

3. Frames and grates for dry well Structure Numbers 100, 110, 111, 115, and 121 shall be Neenah R-1714 or approved equal.

## 2.10 INLINE BASINS

A. Inline basins shall be ADS Nyloplast structures, or approved equal, as detailed on the plans.

# PART 3 - EXECUTION

## 3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

## 3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install PE corrugated sewer piping according to ASTM D 2321.
3. Install PVC cellular-core piping according to ASTM D 2321 and ASTM F 1668.
4. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
5. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.

6. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

## 3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
2. Join PVC cellular-core piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.
3. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
4. Join PVC profile gravity sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
5. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.

## 3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Heavy-Duty, top-loading classification.

B. Set cleanout frames and covers in earth with tops 1 inch above surrounding earth grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

## 3.5 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set frames and covers to elevations indicated.

## 3.6 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

## 3.7 DRY WELL INSTALLATION

A. Construct dry wells to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

## 3.8 INLINE BASINS

A. Construct inline basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

## 3.9 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

## 3.10 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 221413 "Facility Storm Drainage Piping."

## 3.11 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use detectable warning tape over nonferrous piping and over edges of underground structures.

## 3.12 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

2. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
3. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    b. Option: Test plastic piping according to ASTM F 1417.
    c. Option: Test concrete piping according to ASTM C 924.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

## 3.13 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION 334100

# SECTION 334600 - SUBDRAINAGE

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Perforated-wall pipe and fittings.
2. Geotextile filter fabrics.

### 1.3 ACTION SUBMITTALS

A. Product Data:

1. Perforated-wall pipe, including rated capacities.
2. Geotextile filter fabrics.

## PART 2 - PRODUCTS

### 2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings:

1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
3. Couplings: Manufacturer's standard, band type.

B. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.

### 2.2 SOIL MATERIALS

A. Soil materials are specified in Section 312000 "Earth Moving."

## 2.3 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

B. Structure Type: Nonwoven, needle-punched continuous filament.

1. Survivability: AASHTO M 288 Class 2.
2. Styles: Flat and sock.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

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

## 3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

## 3.3 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.

1. Install piping as indicated in the plans.
2. Lay perforated pipe with perforations down.
3. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

## 3.4 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.

B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

## 3.5 CONNECTIONS

A. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

## 3.6 IDENTIFICATION

A. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Section 312000 "Earth Moving."

1. Install detectable warning tape over nonferrous piping and over edges of underground structures.

## 3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

## 3.8 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 334600

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