



Pompano Beach City Hall & Parking Deck

Project Manual

Volume 2

Prepared for

RocaPoint Partners and City of Pompano Beach

DESIGN DEVELOPMENT

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SECTION 000110 - TABLE OF CONTENTS

INDEX OF DESIGN PROFESSIONALS

O Owner: RP Pompano LLC
A Architect: HOK
C Civil Engineer and Landscape Architect: Moore Bass Consulting, Inc.
LA Landscape Architect: HOK
S Structural Engineer: HOK
FP Fire Protection Engineer: Hammond & Associates, Inc.
P Plumbing Engineer: HOK
M Mechanical Engineer: Hammond & Associates, Inc.
E Electrical Engineer: HOK
VT Vertical Transportation Consultant: VDA
PAR Parking Consultant: THA Consulting Inc.

NOTES:

1. Responsibility is noted for entire Division, if all the sections within Division are authored by the same firm, and for individual sections within a Division, if different firms prepared them.
2. Sections are dated with submission's issue date in the page header, unless otherwise noted.

VOLUME 1

SECTION #	SECTION TITLE	ISSUE DATE	REVISION

DIVISION 00 PROCUREMENT AND CONTRACTING REQUIREMENTS (A)

000000	COVER PAGE
000001	COVER BACK PAGE
000110	TABLE OF CONTENTS
003132	GEOTECHNICAL DATA

DIVISION 01 GENERAL REQUIREMENTS (A)

011000	SUMMARY
012300	ALTERNATES
012500	SUBSTITUTION PROCEDURES
012501	SUBSTITUTION REQUEST FORM - HOK
012600	CONTRACT MODIFICATION PROCEDURES
012900	PAYMENT PROCEDURES
013100	PROJECT MANAGEMENT AND COORDINATION
013200	CONSTRUCTION PROGRESS DOCUMENTATION
013233	PHOTOGRAPHIC DOCUMENTATION
013300	SUBMITTAL PROCEDURES
014000	QUALITY REQUIREMENTS
014200	REFERENCES
014339	MOCKUPS
015000	TEMPORARY FACILITIES AND CONTROLS
015731	LEED INDOOR AIR QUALITY MANAGEMENT
016000	PRODUCT REQUIREMENTS
016116	FLORIDA PRODUCT APPROVAL REQUIREMENTS
017300	EXECUTION
017410	CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
017700	CLOSEOUT PROCEDURES
017823	OPERATION AND MAINTENANCE DATA

SECTION #	SECTION TITLE	ISSUE DATE	REVISION
017839	PROJECT RECORD DOCUMENTS		
017900	DEMONSTRATION AND TRAINING		
018113	SUSTAINABLE DESIGN REQUIREMENT – LEED V4/v4.1 BD+C: NEW CONSTRUCTION LEED SCORECARD LEED SUBMITTAL COVER SHEET		
019113	GENERAL COMMISSIONING REQUIREMENTS		
019119	EXTERIOR ENCLOSURE COMMISSIONING		
DIVISION 02	EXISTING CONDITIONS (NOT USED)		
DIVISION 03	CONCRETE (S)		
031000	CONCRETE FORMWORK (S)		
032000	CONCRETE REINFORCEMENT (S)		
033000	CAST-IN-PLACE CONCRETE (S)		
034500	PRECAST ARCHITECTURAL CONCRETE (A)		
035416	HYDRAULIC CEMENT UNDERLAYMENT (A)		
DIVISION 04	MASONRY		
042000	UNIT MASONRY		
DIVISION 05	METALS		
051200	STRUCTURAL STEEL (S)		
053000	METAL DECKING (S)		
054000	COLD FORMED METAL FRAMING		
055000	METAL FABRICATIONS		
055113	METAL PAN STAIRS		
055116	METAL FLOOR PLATE STAIRS		
055119	METAL GRATING STAIRS		
055213	PIPE AND TUBE RAILINGS		
057000	DECORATIVE METAL		
057100	DECORATIVE METAL STAIRS		
057313	GLAZED DECORATIVE METAL RAILINGS		
057500	DECORATIVE FORMED METAL		
DIVISION 06	WOOD, PLASTICS, AND COMPOSITES		
061053	MISCELLANEOUS ROUGH CARPENTRY		
061600	SHEATHING		
064000	ARCHITECTURAL WOODWORK		
064116	PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS		
DIVISION 07	THERMAL AND MOISTURE PROTECTION		
070543	CLADDING SUPPORT SYSTEMS		
071326	SELF-ADHERING SHEET WATERPROOFING		
071616	CRYSTALLINE WATERPROOFING		
071710	HYDROPHILIC WATERSTOPS		
071800	TRAFFIC COATINGS		
071900	WATER REPELLENTS		

SECTION #	SECTION TITLE	ISSUE DATE	REVISION
072100	THERMAL INSULATION		
072150	SPRAYED ACOUSTICAL INSULATION		
072726	FLUID-APPLIED MEMBRANE AIR BARRIERS		
074113.16	STANDING-SEAM METAL ROOFING		
074213.13	FORMED METAL WALL PANELS		
074246	ULTRA-HIGH PERFORMANCE CEMENT PANELS		
074293	SOFFIT PANELS		
075416	KETONE ETHYLENE ESTER (KEE) ROOFING		
075600	FLUID-APPLIED ROOFING		
076200	SHEET METAL FLASHING AND TRIM		
076500	FLEXIBLE FLASHING		
077100	ROOF SPECIALTIES		
077200	ROOF ACCESSORIES		
078100	APPLIED FIREPROOFING		
078413	PENETRATION FIRESTOPPING		
078446	FIRE-RESISTIVE JOINT SYSTEMS		
079100	PREFORMED JOINT SEALS		
079200	JOINT SEALANTS		
DIVISION 08 OPENINGS			
081113	HOLLOW METAL DOORS AND FRAMES		
081416	FLUSH WOOD DOORS		
081713	INTEGRATED METAL DOOR ASSEMBLIES		
083113	ACCESS DOORS AND FRAMES		
083336	SIDE COILING GRILLES		
084113	ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS		
084229	SLIDING AUTOMATIC ENTRANCES		
084413	GLAZED ALUMINUM CURTAIN WALLS		
084435	FIRE-RATED GLAZED ASSEMBLIES		
084443	SUN CONTROL DEVICES		
087100	DOOR HARDWARE		
087113	POWER DOOR OPERATORS		
088000	GLAZING		
088300	MIRRORS		
089000	LOUVERS		
DIVISION 09 FINISHES			
090561.13	MOISTURE VAPOR EMISSION CONTROL		
092100	GYPSUM BOARD ASSEMBLIES		
092713	GLASS-FIBER-REINFORCED GYPSUM FABRICATIONS		
093100	TILING		
095113	ACOUSTICAL PANEL CEILINGS		
095422	POLYESTER FELT CEILING ASSEMBLIES		
095426	SUSPENDED WOOD CEILINGS		
096513	RESILIENT BASE AND ACCESSORIES		
096516	RESILIENT SHEET FLOORING		
096519	RESILIENT TILE FLOORING		
096536	STATIC-CONTROL RESILIENT FLOORING		
096723	RESINOUS FLOORING		
096813	TILE CARPETING		
096818	SHEET CARPETING		

SECTION #	SECTION TITLE	ISSUE DATE	REVISION

097200	WALL COVERINGS		
097815	WOOD INTERIOR WALL PANELING		
098453	SOUND BARRIER MULLION TRIM CAP		
099100	PAINTING		
099611	HIGH-PERFORMANCE COATINGS		

DIVISION 10 SPECIALTIES

101100	VISUAL DISPLAY UNITS		
101400	SIGNAGE		
101500	GRAPHIC ELEMENTS		
102113	TOILET COMPARTMENTS		
102123	CUBICLE CURTAINS AND TRACK		
102239	FOLDING PANEL PARTITIONS		
102239.16	OPERABLE GLASS-PANEL PARTITIONS		
102513	FACTORY-FABRICATED MODULAR HEADWALL SYSTEM		
102600	WALL AND DOOR PROTECTION		
102800	TOILET, BATH, AND LAUNDRY ACCESSORIES		
104146	EMERGENCY KEY CABINETS		
104313	DEFIBRILLATOR CABINETS		
104413	FIRE PROTECTION CABINETS		
104416	FIRE EXTINGUISHERS		
105123	PLASTIC-LAMINATE-CLAD LOCKERS		
107316.13	METAL CANOPIES		

DIVISION 11 EQUIPMENT

111300	LOADING DOCK EQUIPMENT		
113013	RESIDENTIAL APPLIANCES		
118124	BUILDING MAINTENANCE ACCESS EQUIPMENT		

DIVISION 12 FURNISHINGS

122413	ROLLER WINDOW SHADES		
123661.16	SOLID SURFACING COUNTERTOPS		
123661.19	QUARTZ AGGLOMERATE COUNTERTOPS		
124813	ENTRANCE FLOOR MATS AND FRAMES		

DIVISION 13 SPECIAL CONSTRUCTION

131213	EXTERIOR FOUNTAINS		
133100	TENSILE MEMBRANE STRUCTURES		

DIVISION 14 CONVEYING EQUIPMENT (VT)

142123	MRL TRACTION ELEVATORS		

APPENDIX A

Subsurface Exploration and Geotechnical Engineering Report

SECTION #	SECTION TITLE	ISSUE DATE	REVISION

VOLUME 2

SECTION #	SECTION TITLE	ISSUE DATE	REVISION

DIVISION 21 FIRE PROTECTION (FP)

210500	COMMON WORK RESULTS FOR FIRE SUPPRESSION
210513	COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT
210523	GENERAL-DUTY VALVES FOR WATER-BASED FIRE SUPPRESSION PIPING
210553	IDENTIFICATION FOR FIRE SUPPRESSION PIPING AND EQUIPMENT
211200	FIRE-SUPPRESSION STANDPIPES
211300	FIRE-SUPPRESSION SPRINKLER SYSTEMS
212200	CLEAN-AGENT FIRE-EXTINGUISHING SYSTEM
213000	FIRE PUMPS

DIVISION 22 PLUMBING (P)

220500	COMMON WORK RESULTS FOR PLUMBING
220523	GENERAL-DUTY VALVES FOR PLUMBING PIPING
220529	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
220548.13	VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT
220553	IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
220593	TESTING, ADJUSTING, AND BALANCING FOR PLUMBING
220716	PLUMBING EQUIPMENT INSULATION
220719	PLUMBING PIPING INSULATION
220800	COMMISSIONING OF PLUMBING
221116	DOMESTIC WATER PIPING
221119	DOMESTIC WATER PIPING SPECIALTIES
221123.21	INLINE, DOMESTIC WATER PUMPS
221316	SANITARY WASTE AND VENT PIPING
221319	SANITARY WASTER PIPING SPECIALTIES
221319.13	SANITARY DRAINS
221414	STORM DRAINAGE PIPING
221423	STORM DRAINAGE PIPING SPECIALTIES
21429	SUMP PUMPS
223300	ELECTRIC DOMESTIC-WATER HEATERS
224200	COMMERCIAL PLUMBING FIXTURES
224700	DRINKING FOUNTAINS AND WATER COOLERS

DIVISION 23 HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC) (M)

230529	HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
230548	VIBRATION AND SEISMIC CONTROLS FOR HVAC
230553	IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
230593	TESTING, ADJUSTING, AND BALANCING FOR HVAC
230713	DUCT INSULATION

SECTION #	SECTION TITLE	ISSUE DATE	REVISION
230719	HVAC PIPING INSULATION		
230993	SEQUENCE OF OPERATIONS FOR HVAC CONTROLS		
232300	REFRIGERANT PIPING		
233100	HVAC DUCTS AND CASINGS		
233300	AIR DUCT ACCESSORIES		
233319	DUCT SILENCERS		
233416	CENTRIFUGAL HVAC FANS		
233423	HVAC POWER VENTILATORS		
263600	AIR TERMINAL UNITS		
233700	AIR OUTLETS AND INLET		
237416	PACKAGED ROOFTOP AIR-CONDITIONING UNITS		
238126.13	SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS		
238129	VARIABLE REFRIGERANT FLOW HVAC SYSTEMS		
DIVISION 25	INTEGRATED AUTOMATION (NOT USED)		
DIVISION 26	ELECTRICAL (E)		
260010	SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL		
260519	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES		
260526	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS		
260529	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS		
260533	RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS		
260533.13	CONDUITS FOR ELECTRICAL SYSTEMS		
260533.16	BOXES AND COVERS FOR ELECTRICAL SYSTEMS		
260533.23	SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS		
260536	CABLE TRAYS FOR ELECTRICAL SYSTEMS		
260544	SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING		
220548	VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS		
260553	IDENTIFICATION FOR ELECTRICAL SYSTEMS		
260573	POWER SYSTEM STUDIES		
260800	COMMISSIONING OF ELECTRICAL SYSTEMS		
260923	LIGHTING CONTROL DEVICES		
260943.23	RELAY-BASED LIGHTING CONTROLS		
262213	LOW-VOLTAGE TRANSFORMERS		
262413	SWITCHBOARDS		
262416	PANELBOARDS		
262716	ELECTRICAL CABINETS AND ENCLOSURES		
262726	WIRING DEVICES		
262816	ENCLOSED SWITCHES AND CIRCUIT BREAKERS		
262913	ENCLOSED CONTROLLERS		
263213.13	DIESEL-ENGINE-DRIVEN GENERATOR SETS		
263343	BATTERY CHARGERS		
263600	TRANSFER SWITCHES		
264113	LIGHTNING PROTECTION FOR STRUCTURES		
264300	SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS		
265000	LIGHTING		
DIVISION 27	COMMUNICATIONS (AV/TC)		

SECTION #	SECTION TITLE	ISSUE DATE	REVISION
270500	COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS		
270526	GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS		
270528	PATHWAYS FOR COMMUNICATIONS SYSTEMS		
270528.29	HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS		
270536	CABLE TRAYS FOR COMMUNICATIONS SYSTEMS		
270544	SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS SYSTEMS		
270553	IDENTIFICATION FOR COMMUNICATIONS SYSTEMS		
271100	COMMUNICATIONS EQUIPMENT ROOM FITTINGS		
271323	COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING		
271500	COMMUNICATIONS COPPER HORIZONTAL CABLING		
DIVISION 28	ELECTRONIC SAFETY AND SECURITY (E)		
280500	COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY		
280513	CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY		
280520	CABINETS AND ENCLOSURES FOR ELECTRONIC SAFETY AND SECURITY		
280526	GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY		
280528	PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS		
280528.29	HANGERS AND SUPPORTS FOR ELECTRONIC SAFETY AND SECURING SYSTEMS		
280544	SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS		
	PATHWAYS CABLING		
281300	ACCESS CONTROL SYSTEMS FOR ELECTRONIC SAFETY AND SECURITY		
282300	VIDEO SURVEILLANCE FOR ELECTRONIC SAFETY AND SECURITY		
284600	FIRE DETECTION AND ALARM		

SECTION #	SECTION TITLE	ISSUE DATE	REVISION

DIVISION 31 - EARTHWORK

ADDITIONAL SPECIFICATION INFORMATION PROVIDED ON CIVIL ENGINEERING DRAWINGS

DIVISION 32 - EXTERIOR IMPROVEMENTS (LA)

321316	DECORATIVE CONCRETE PAVING
321400	UNIT PAVING
321540	CRUSHED STONE SURFACING
323300	SITE FURNISHINGS
328400	PLANTING IRRIGATION
329113	SOIL PREPARATION
329200	TURF AND GRASSES
329300	PLANTS

DIVISION 33 - UTILITIES

ADDITIONAL SPECIFICATION INFORMATION PROVIDED ON CIVIL ENGINEERING DRAWINGS

END OF TABLE OF CONTENTS

SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Above ground piping.
- B. Expansions - hose and braid.
- C. Mechanical couplings.
- D. Mechanical pressed fittings.
- E. Pipe hangers and supports.
- F. Pipe sleeves.
- G. Pipe sleeve-seal systems.
- H. Piping specialties.
- I. Pressure gauges.
- J. Pressure relief valves.

1.2 RELATED REQUIREMENTS

- A. Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- B. Section 210553 - Identification for Fire Suppression Piping and Equipment: Piping identification.
- C. Section 211200 - Fire-Suppression Standpipes: Standpipe design.
- D. Section 211300 - Fire-Suppression Sprinkler Systems: Sprinkler systems design.

1.3 REFERENCE STANDARDS

- A. ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems; 2015 (Reaffirmed 2020).
- B. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.
- C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard; 2025.
- D. ASME B16.9 - Factory-Made Wrought Butt welding Fittings; 2024.
- E. ASME B16.11 - Forged Fittings, Socket-Welding and Threaded; 2021.

- F. ASME B16.25 - Buttwelding Ends; 2022.
- G. ASME B36.10M - Welded and Seamless Wrought Steel Pipe; 2022.
- H. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2024.
- I. ASTM A135/A135M - Standard Specification for Electric-Resistance-Welded Steel Pipe; 2021.
- J. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2025.
- K. ASTM A536 - Standard Specification for Ductile Iron Castings; 2024.
- L. ASTM A795/A795M - Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use; 2021.
- M. AWWA C606 - Grooved and Shouldered Joints; 2022.
- N. FM (AG) - FM Approval Guide; Current Edition.
- O. ITS (DIR) - Directory of Listed Products; Current Edition.
- P. NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- Q. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems; 2024.
- R. NFPA 1963 - Standard for Fire Hose Connections; 2019.
- S. UL (DIR) - Online Certifications Directory; Current Edition.
- T. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.
- U. UL 405 - Standard for Safety Fire Department Connection Devices; Current Edition, Including All Revisions.
- V. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information. Indicate valve data and ratings.
- C. Shop Drawings: Indicate pipe materials used, jointing methods, supports, and floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- D. Operation and Maintenance Data: Include installation instructions and spare parts lists.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified in this section.
 - 1. Minimum three years experience.
- C. Valves: Bear product listing label or marking. Provide manufacturer's name and pressure rating marked on valve body.
- D. Products Requiring Electrical Connection: Listed and classified as suitable for the purpose specified and indicated.
- E. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary protective coating on cast iron and steel valves.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Combined Sprinkler, Standpipe, and Hose System:
 - 1. Comply with NFPA 13 and NFPA 14.
 - 2. See Sections 211300 and 211200.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX.
- C. Provide system pipes, fittings, sleeves, escutcheons, seals, and other related accessories.

2.2 ABOVE GROUND PIPING

- A. Steel Pipe: ASTM A795 Schedule 10, ASME B36.10M Schedule 5, ASTM A53 Schedule 40, ASTM A135/A135M Schedule 10, ASTM A135/A135M UL listed light wall type, or ASTM A795 Schedule 40, black.
 - 1. Steel Fittings: ASME B16.9 wrought steel, buttwelded, ASME B16.25 buttweld ends, ASTM A234/A234M wrought carbon steel or alloy steel, ASME B16.5 steel flanges and fittings, or ASME B16.11 forged steel socket welded and threaded.
 - 2. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

2.3 PIPE SLEEVES

- A. Vertical Piping:
 - 1. Sleeve Length: 1 inch (25 mm) above finished floor.
 - 2. Provide sealant for watertight joint.

2.4 PIPE SLEEVE-SEAL SYSTEMS

- A. Modular Mechanical Seals:
 - 1. Elastomer-based interlocking links to continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
 - 2. Watertight seal between pipe and wall-sleeve, wall or casing opening.
 - 3. Size and select seal component materials in accordance with service requirements.
 - 4. Service Requirements:
 - a. Underground, buried, and wet conditions.
 - 5. Glass-reinforced plastic pressure end plates.
- B. Wall Sleeve: PVC material with waterstop collar, and nailer end caps.
- C. Sleeve-Forming Disk: Nonconductive plastic-based material, 3 inch (76.2 mm) thick.
- D. Pipeline-Casing Seals:
 - 1. End Seals: 1/8 inch (3.1 mm), pull-on type, rubber or synthetic rubber based.

2.5 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 inch (15 to 40 mm): Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipe Sizes 2 inches (50 mm) and Over: Carbon steel, adjustable, clevis.
- C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- D. Wall Support for Pipe Sizes to 3 inches (80 mm): Cast iron hook.
- E. Wall Support for Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp.
- F. Vertical Support: Steel riser clamp.
- G. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

2.6 EXPANSION JOINTS AND LOOPS - HOSE AND BRAID

- A. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.

1. Maximum Allowable Working Pressure: 150 psig (1030 kPa) at 120 degrees F (49 degrees C).
2. Accommodate the Following:
 - a. Axial Deflection in Compression and Expansion: _____ inch (_____ mm).
 - b. Lateral Movement: _____ inch (_____ mm).
 - c. Angular Rotation: 15 degrees.
 - d. Force developed by 1.5 times specified maximum allowable operating pressure.
3. Provide necessary accessories including, but not limited to, swivel joints.

2.7 MECHANICAL COUPLINGS

A. Rigid Mechanical Couplings for Grooved Joints:

1. Dimensions and Testing: Comply with AWWA C606.
2. Minimum Working Pressure: 300 psig (2065 kPa).
3. Housing Material: Fabricate of ductile iron complying with ASTM A536.
4. Housing Coating: Factory applied orange enamel.
5. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F (minus 34 degrees C) to 230 degrees F (110 degrees C).
6. Bolts and Nuts: Hot-dipped-galvanized or zinc-electroplated steel.

2.8 MECHANICAL PRESSED FITTINGS

- ### **A. Provide double-pressed type, utilizing EPDM, nontoxic, synthetic rubber sealing elements for use with Schedule 40 carbon steel piping.**

2.9 PIPING SPECIALTIES

- ### **A. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber-faced clapper to automatically actuate water motor alarm, pressure retard chamber and variable pressure trim with the following additional capabilities and features:**

1. Activate electric alarm.
2. Test and drain valve.
3. Replaceable internal components without removing valve from installed position.
4. Manufacturers:
 - a. Victaulic Company; Series 751 with Series 760 motor alarm: www.victaulic.com/#sle.

- ### **B. Backflow Preventer: Reduced-pressure principle valve assembly backflow preventer with drain and OS & Y gate valve on each end.**

C. Test Connections:

1. Combination Inspector's Test Connection and Drain Valve:
 - a. Provide test connections approximately 6 feet (2 m) above floor for each or portion of each sprinkler system equipped with an alarm device, located at most remote part of each system.
 - b. Route combination test connection and drain valve to an open-site drain location, excluding janitor sinks, accepting full flow without negative consequences.
 - c. Supply discharge orifice with same size as corresponding sprinkler orifice.

- d. Limit vertical height of exterior wall penetration to 2 feet (0.61 m) above finished grade.
- 2. Backflow Preventer Test Connection:
 - a. Provide downstream of the backflow prevention assembly, listed hose valves with 2.5-inch (65 mm) National Standard male hose threads with cap and chain.
 - b. Provide one valve for each 250 gpm (16 L/sec) of system demand or fraction thereof.
 - c. Provide permanent sign reading "Test Valve." See Section 210553.
- D. Electric Alarm: Electrically operated chrome-plated gong with pressure alarm switch.
- E. Water Flow Switch: Vane-type switch for mounting horizontally or vertically, with two contacts; rated 10 A at 125 VAC and 2.5 A at 24 VDC.
- F. Fire Department Connections:
 - 1. Type: Free standing made of corrosion-resistant metal complying with UL 405.
 - a. Inlets: Two-way, 2-1/2 inch (65 DN) swivel fittings, internal threaded. Thread size and inlets according to NFPA 1963 or authority having jurisdiction. Brass caps with gaskets, chains, and lugs.
 - b. Configuration: Horizontal.
 - c. Outlet: Bottom with pipe threads, 4 NPS (100 DN).
 - 1) Location: Back.
 - d. Rated Working Pressure: 175 psi (1200 kPa).
 - e. Finish: Chrome.
 - f. Sleeve: Brass, 18-inch (460 mm) height.
 - g. Signage: Raised or engraved lettering 1 inch (25.4 mm), minimum, indicating system type.
- G. Supervisory Switches:
- H. Water Level Supervisory Switches:

2.10 PRESSURE GAUGES

- A. Pressure Gauges: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
 - 1. Case: Steel with brass bourdon tube.
 - 2. Diameter: 4-1/2 inch (115 mm).
 - 3. Mid-Scale Accuracy: One percent.
 - 4. Scale: Display in psi and kPa.

2.11 PRESSURE RELIEF VALVES

- A. ANSI Z21.22, AGA certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

PART 3 EXECUTION

3.1 PREPARATION

- A. Remove scale and foreign material, from inside and outside, before assembly.
- B. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Install sprinkler system and service main piping, hangers, and supports in accordance with NFPA 13.
- B. Install standpipe piping, hangers, and supports in accordance with NFPA 14.
- C. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- D. Install piping to conserve building space, to not interfere with use of space and other work.
- E. Group piping whenever practical at common elevations.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Pipe Hangers and Supports:
 - 1. Install hangers to provide minimum 1/2 inch (15 mm) space between finished covering and adjacent work.
 - 2. Place hangers within 12 inches (300 mm) of each horizontal elbow.
 - 3. Use hangers with 1-1/2 inch (40 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 4. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 5. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- I. Prepare pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welding.
- J. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
- K. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.

4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
5. Tighten bolting for a watertight seal.
6. Install in accordance with manufacturer's recommendations.

L. Escutcheons:

1. Install and firmly attach escutcheons at piping penetrations into finished spaces.
2. Provide escutcheons on both sides of partitions separating finished areas through which piping passes.
3. Use chrome plated escutcheons in occupied spaces and to conceal openings in construction.

- M. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.

3.3 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION 210500

SECTION 210513 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. General construction and requirements.
- B. Applications.
- C. Single phase electric motors.
- D. Three phase electric motors.

1.2 REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering.

PART 2 PRODUCTS

2.1 APPLICATIONS

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.

END OF SECTION 210513

SECTION 210523 - GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Bronze butterfly valves with indicators.
- B. Trim and drain valves.

1.2 RELATED REQUIREMENTS

- A. Section 210553 - Identification for Fire Suppression Piping and Equipment.
- B. Section 211200 - Fire-Suppression Standpipes.
- C. Section 211300 - Fire-Suppression Sprinkler Systems.

1.3 ABBREVIATIONS AND ACRONYMS

- A. EPDM: Ethylene-propylene diene monomer.
- B. NRS: Non-rising stem.
- C. OS&Y: Outside screw and yoke.
- D. PTFE: Polytetrafluoroethylene.

1.4 REFERENCE STANDARDS

- A. FM 1112 - Examination Standard for Indicating Valves (Butterfly or Ball Type); 2020.
- B. FM 1140 - Examination Standard for Quick Opening Valves 1/4 Inch Through 2 Inch Nominal Size; 2024.
- C. UL 258 - Shutoff Valves for Trim and Drain Purposes for Fire Protection Service; Current Edition, Including All Revisions.
- D. UL 1091 - Standard for Butterfly Valves for Fire-Protection Service; Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Use the following precautions during storage:
 - 1. Maintain valve end protection and protect flanges and specialties from dirt.
 - a. Provide temporary inlet and outlet caps.
 - b. Maintain caps in place until installation.
 - 2. Store valves in shipping containers and maintain in place until installation.
 - a. Store valves indoors and maintain at higher than ambient dew point temperature.
 - b. If outdoor storage is unavoidable, store valves off the ground in watertight enclosures.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Furnish valves of same kind by same manufacturer.
- B. Valve Pressure Ratings: Not less than minimum pressure rating indicated or higher as required.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.

2.2 BRONZE BUTTERFLY VALVES WITH INDICATORS

- A. UL 1091 and FM 1112 listed.
- B. Minimum Pressure Rating: 175 psig (1200 kPa).
- C. Body Material: Bronze.
- D. Seat: EPDM.
- E. Stem: Bronze or stainless steel.
- F. Disc: Bronze with EPDM coating or stainless steel.
- G. Actuator: Worm gear or traveling nut.
- H. Supervisory Switch: Internal or external.
- I. End Connections: Threaded or grooved.

2.3 TRIM AND DRAIN VALVES

- A. Ball Valves:
 - 1. Description:
 - a. UL 258 or FM 1140 listed.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Design: Two piece.
 - d. Body Material: Forged brass or bronze.

- e. Port Size: Full or standard.
- f. Seat: PTFE.
- g. Stem: Bronze or stainless steel.
- h. Ball: Chrome-plated brass.
- i. Actuator: Hand-lever.
- j. End Connections: Threaded or grooved.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install valves in accessible locations to allow for operation, inspections, tests, and maintenance.
- B. Install listed valves in accordance with their listing.
- C. Install valves in accordance with manufacturer's instructions.
- D. Support valves independently of adjacent piping.
- E. Install valves in horizontal piping with stem at or above pipe center.
- F. Position valves to allow full actuator movement.
- G. Install OS&Y valves with full clearance for rising stem. Install surrounding components so they do not interfere with nor are they impacted by full extension of rising stem.
- H. Install supervised shutoff valves in supervised-open position.
- I. Install permanent identification signs indicating portion of system controlled by each shutoff valve.
- J. Install threaded-end valves with unions upstream and downstream.
- K. Install valve tags. See Section 210553. Label valves in accordance with NFPA standard applying to the piping system in which valves are installed.

END OF SECTION 210523

SECTION 210553 - IDENTIFICATION FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Stencils.
- D. Pipe markers.
- E. Ceiling tacks.

1.2 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Product Data: Provide manufacturers catalog literature for each product required.
- D. Manufacturer's Installation Instructions: Indicate special procedures, and installation instructions.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A. Automatic Controls: Tags.
- B. Control Panels: Nameplates.
- C. Instrumentation: Tags.
- D. Major Control Components: Nameplates.
- E. Piping: Pipe markers.
- F. Pumps: Nameplates.
- G. Valves: Nameplates and ceiling tacks where above lay-in ceilings.

2.2 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.

2.3 TAGS

- A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.

2.4 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:
 - 1. 3/4 to 1-1/4 inch (20-30 mm) Outside Diameter of Insulation or Pipe: 8 inch (200 mm) long color field, 1/2 inch (15 mm) high letters.
 - 2. 1-1/2 to 2 inch (40-50 mm) Outside Diameter of Insulation or Pipe: 8 inch (200 mm) long color field, 3/4 inch (20 mm) high letters.
 - 3. 2-1/2 to 6 inch (65-150 mm) Outside Diameter of Insulation or Pipe: 12 inch (300 mm) long color field, 1-1/4 inch (30 mm) high letters.
 - 4. 8 to 10 inch (200-250 mm) Outside Diameter of Insulation or Pipe: 24 inch (600 mm) long color field, 2-1/2 inch (65 mm) high letters.
 - 5. Over 10 inch (250 mm) Outside Diameter of Insulation or Pipe: 32 inch (800 mm) long color field, 3-1/2 inch (90 mm) high letters.
 - 6. Equipment: 2-1/2 inch (65 mm) high letters.

2.5 PIPE MARKERS

- A. Color: Comply with ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.

2.6 CEILING TACKS

- A. Description: Steel with 3/4 inch (20 mm) diameter color coded head.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Use tags on piping 3/4 inch (20 mm) diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
- F. Locate ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 210553

SECTION 211200 - FIRE-SUPPRESSION STANDPIPES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fire hose cabinets.
- B. Hose reels and hoses.
- C. Valves.
- D. Fire department connections.

1.2 RELATED REQUIREMENTS

- A. Section 210500 - Common Work Results for Fire Suppression: Fire protection piping.
- B. Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- C. Section 210553 - Identification for Fire Suppression Piping and Equipment.
- D. Section 211300 - Fire-Suppression Sprinkler Systems.
- E. Section 213000 - Fire Pumps.

1.3 REFERENCE STANDARDS

- A. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems; 2024.
- B. NFPA 1963 - Standard for Fire Hose Connections; 2019.
- C. UL 405 - Standard for Safety Fire Department Connection Devices; Current Edition, Including All Revisions.
- D. UL (DIR) - Online Certifications Directory; Current Edition.

1.4 SUBMITTALS

- A. Product Data: Provide manufacturer's catalog sheet for equipment indicating rough-in size, finish, and accessories.
- B. Shop Drawings: Indicate supports, components, accessories, and sizes.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 14.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in shipping packaging until installation.

PART 2 PRODUCTS

2.1 FIRE HOSE CABINETS

- A. Cabinet:
 - 1. Style: Recessed mounted.
 - 2. Door: 12 gauge, 0.1046 inch (2.66 mm) thick steel, flush, glazed with 1/4 inch (6.35 mm) thick wired glass full panel; hinged, positive latch device.
 - 3. Finish: Prime coated.
- B. Hose Rack: Steel with polished chrome finish; swivel type with pins and water stop.
- C. Hose: 1 inch (25 mm, DN) diameter, 50 feet (15 m) long, of linen hose; mildew and rot-resistant.
- D. Nozzle: Chrome plated brass; combination fog, straight stream, and adjustable shut-off.

2.2 HOSE REELS AND HOSES

- A. Construction:
 - 1. Red enameled hose reels, frames, and accessories suitable for hose length and diameter.
 - 2. Reels fitted with swivel and piping to allow continuous flow through hoses.
 - 3. Friction breaks to prevent hoses from accidental unwinding.
- B. Hoses:
 - 1. Construction: Flexible 3-braid, single-jacket, hard rubber or heavy duty synthetic red cover, non-collapsible, non-kinking, and fitted with couplings.
- C. Couplings: Provide hole type couplings, one female and one male, both with chemical hose thread _____.
- D. Control Valve: 175 psi (1,200 kPa) rated, quarter turn, ball for quick-opening operation.
- E. Hose Nozzle: 1-1/2 inch NPS (40 mm, DN) chemical hose thread, polished brass, adjustable fog, off-and-on solid-stream type.

2.3 VALVES

- A. Specialty Valves:
 - 1. Hose Connection Valve:

- a. Angle type; brass finish; 2-1/2 inch NPS (65 mm, DN), thread to match fire department hardware, 300 psi (2,070 kPa) working pressure, with threaded cap and chain of same material and finish.
 2. In-line or Angle Hose Valves:
 - a. Cast bronze, 2-1/2 inch, NPS (65 mm, DN) handwheel operated globe valve with grooved or threaded end connections, rated for 400 psi (2,760 kPa) inlet pressure with outlet discharge field-set to hose inlet pressure.
 3. In-line or Angle Floor Control Valves:
 - a. Cast bronze, 2-1/2 inch, NPS (65 mm, DN) handwheel operated globe valve with grooved or threaded end connections, rated for 400 psi (2,760 kPa) maximum inlet pressure with outlet discharge field-set to system inlet pressure. Provide integral normally-open supervisory switch, cap, and chain.
- B. Hose Connection Valve Cabinets:
 1. Style: Recessed mounted.
 2. Tub: 16 gauge, 0.0598 inch (1.52 mm) thick steel, prepared for pipe and accessory rough-in.
 3. Door: 12 gauge, 0.1046 inch (2.66 mm) thick steel, flush, glazed with 1/4 inch (6.35 mm) thick wired glass full panel; hinged, positive latch device.
 4. Finish: Prime coated.

2.4 FIRE DEPARTMENT CONNECTIONS

- A. Type: Free standing made of corrosion resistant metal complying with UL 405.
 1. Inlets: Two-way, 2-1/2 inch (65 mm, DN) swivel fittings, internal threaded. Thread size and inlets according to or Authority Having Jurisdiction. Brass caps with gaskets, chains, and lugs.
 2. Configuration: Horizontal.
 3. Rated Working Pressure: 175 psi (1200 kPa).
 4. Finish: Chrome.
 5. Sleeve: Brass, 18 inches (460 mm) height.
 6. Signage: Raised or engraved lettering 1 inch (25.4 mm) minimum indicating system type.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA 14.
- C. Locate and secure cabinets plumb and level. Establish top of cabinet (inside horizontal) surface 66 inches (1675 mm) above finished floor.
- D. Connect standpipe system to water source ahead of domestic water connection.
- E. Flush entire system of foreign matter.

END OF SECTION 211200

SECTION 211300 - FIRE-SUPPRESSION SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Wet-pipe sprinkler system.
- B. System design, installation, and certification.
- C. Fire department connections.

1.2 RELATED REQUIREMENTS

- A. Section 210500 - Common Work Results for Fire Suppression: Pipe and fittings.
- B. Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- C. Section 210553 - Identification for Fire Suppression Piping and Equipment.
- D. Section 211200 - Fire-Suppression Standpipes.
- E. Section 213000 - Fire Pumps.

1.3 REFERENCE STANDARDS

- A. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry; 2018, with Editorial Revision (2020).
- B. NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NFPA 1963 - Standard for Fire Hose Connections; 2019.
- D. UL (DIR) - Online Certifications Directory; Current Edition.
- E. UL 405 - Standard for Safety Fire Department Connection Devices; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Shop Drawings:

1. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components, and accessories. Indicate system controls.
 2. Submit shop drawings to Authorities Having Jurisdiction for approval. Submit proof of approval to Architect.
- D. Samples: Submit two of each style of sprinkler specified.
- E. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 016000 - Product Requirements for additional provisions.
 2. Extra Sprinklers: Type and size matching those installed in quantity required by referenced NFPA design and installation standard.
 3. Sprinkler Wrenches: For each sprinkler type.
- G. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.

1.5 QUALITY ASSURANCE

- A. Maintain one copy of referenced design and installation standard on site.
- B. Comply with FM (AG) requirements.
- C. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
- D. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Sprinklers, Valves, and Equipment:
1. Anvil International; _____: www.anvilintl.com/#sle.
 2. Tyco Fire Protection Products; _____: www.tyco-fire.com/#sle.
 3. Viking Corporation; _____: www.vikinggroupinc.com/#sle.

2.2 SPRINKLER SYSTEM

- A. Sprinkler System: Provide coverage for entire building.
- B. Occupancy: Light hazard; comply with NFPA 13.
- C. Water Supply: Determine volume and pressure from water flow test data.
- D. Provide fire department connections where indicated.
- E. Storage Cabinet for Spare Sprinklers and Tools: Steel, located adjacent to alarm valve.

2.3 SPRINKLERS

- A. Suspended Ceiling Type: Semi-recessed pendant type with matching push on escutcheon plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- B. Exposed Area Type: Upright type with guard.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: Brass.
 - 4. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- C. Sidewall Type: Semi-recessed horizontal sidewall type with matching push on escutcheon plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: Brass.
 - 4. Escutcheon Plate Finish: Brass.
 - 5. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- D. Flexible Drop System: Stainless steel, multiple use, open gate type.
 - 1. Application: Use to properly locate sprinkler heads.
 - 2. Include all supports and bracing.
 - 3. Provide braided type tube as required for the application.
 - 4. Manufacturers:

2.4 PIPING SPECIALTIES

- A. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber-faced clapper to automatically actuate water motor alarm, pressure retard chamber and variable pressure trim with the following additional capabilities and features:
 - 1. Activate electric alarm.
 - 2. Test and drain valve.
 - 3. Replaceable internal components without removing valve from installed position.

- B. Electric Alarm: Electrically operated chrome plated gong with pressure alarm switch.
- C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC.
- D. Fire Department Connections:
 - 1. Type: Free standing made of corrosion resistant metal complying with UL 405.
 - a. Inlets: Two way, 2-1/2 inch (65 DN) swivel fittings, internal threaded. Thread size and inlets according to NFPA 1963 or Authority Having Jurisdiction. Brass caps with gaskets, chains, and lugs.
 - b. Rated Working Pressure: 175 psi (1200 kPa).
 - c. Finish: Chrome.
 - d. Sleeve: Brass, 18 inches (460 mm) height.
 - e. Signage: Raised or engraved lettering 1 inch (25.4 mm) minimum indicating system type.
- E. Supervisory Switches:
 - 1. Manufacturers:
 - a. Potter Electric Signal Company, LLC; CoilKeeper Solenoid Supervisory Switch: www.pottersignal.com/#sle.

2.5 PRESSURE MAINTENANCE PUMP

- A. Type: Close coupled motor and positive displacement pump unit.
- B. Construction: Bronze with stainless steel shafts, carbon bearings.
- C. Motor: Open drip-proof, permanently lubricated.
- D. Accessories: Include flexible hose connections.
- E. Operation: Manual.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with referenced NFPA design and installation standard.
- B. Install equipment in accordance with manufacturer's instructions.
- C. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent siamese connectors to allow full swing of fire department wrench handle.
- D. Locate outside alarm gong on building wall as indicated.
- E. Place pipe runs to minimize obstruction to other work.
- F. Place piping in concealed spaces above finished ceilings.

- G. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.
- H. Install and connect to fire pump system in accordance with Section 213000.
- I. Flush entire piping system of foreign matter.
- J. Hydrostatically test entire system.
- K. Require test be witnessed by Fire Marshal.

3.2 INTERFACE WITH OTHER PRODUCTS

- A. Ensure required devices are installed and connected as required to fire alarm system.

END OF SECTION 211300

SECTION 212200 - CLEAN-AGENT FIRE-EXTINGUISHING SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fire suppression system control panel.
- B. Space or area signage.
- C. System piping and specialties.
- D. Clean-agent containers.
- E. Agent discharge nozzles.

1.2 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

- A. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- C. ASME B31.1 - Power Piping; 2024.
- D. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.
- E. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2024.
- F. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2019a.
- G. ASTM A135/A135M - Standard Specification for Electric-Resistance-Welded Steel Pipe; 2021.
- H. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2025.
- I. ITS (DIR) - Directory of Listed Products; Current Edition.
- J. NEMA IA 10030 - Industrial Control and Systems: Enclosures; 2024.
- K. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

- L. NFPA 72 - National Fire Alarm and Signaling Code; Most Recent Edition Cited by Referring Code or Reference Standard.
- M. NFPA 2001 - Standard on Clean Agent Fire Extinguishing Systems; 2025.
- N. UL (DIR) - Online Certifications Directory; Current Edition.
- O. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.
- P. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide system and component data bearing approval stamp from Authority Having Jurisdiction. Include detectors, release devices, discharge nozzles, manual controls, alarm devices, annunciators, extinguishing agent containers, manifolds, and control panel.
- C. Shop Drawings:
 - 1. Floor Plan(s): System layout with proposed raceway, piping, and component locations with a minimum drawing scale of 1/8 inch to 1 foot (1:100), use larger scale for details.
 - 2. Schematics: System riser, control and wiring diagrams with written sequence of operation.
- D. Manufacturer's Instructions: Include recommended equipment installation and system components.
- E. Test Reports: Indicate successful completion of tests; include certification of extinguishing agent container pressure and extinguishing agent quantity.
- F. Code Authority Approval: Submit copy of inspection approval of fire protection system by Authority Having Jurisdiction.
- G. Designer's qualification statement.
- H. Installer's qualification statement.
- I. Project Record Documents: Record actual locations of components and equipment, equipment identification markings, conduit and piping routing details, and agent container positions.
- J. Operation and Maintenance Data:
 - 1. Include electrical schematic written description of system design, drawings illustrating control logic and equipment locations, and technical brochures describing equipment.
 - 2. Include manufacturer recommended spare parts list.
 - 3. Include checklists and procedures for emergencies, troubleshooting techniques, abort functions, system control panel operation, trouble procedures, and safety requirements.

1.5 QUALITY ASSURANCE

- A. Designer Qualifications: Perform design under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State in which the Project is located.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years documented experience.
- C. Installer Qualifications: Company specializing in performing work of the type specified and with at least five years of documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store equipment in shipping containers with labeling in place. Deliver fire extinguishing agent in approved containers.

PART 2 PRODUCTS

2.1 CLEAN-AGENT FIRE SUPPRESSION SYSTEM REQUIREMENTS

- A. Engineered fire detection and suppression system that totally floods protected area with clean-agent fire extinguishing agent to extinguish fire.
 - 1. Fire Extinguishing Agent: Any allowed by NFPA 2001.
 - 2. Locate extinguishing agent supply and backup supply in each protected area.
 - 3. Locate manual release stations at each exit from protected area.
 - 4. Locate abort stations at each exit from protected area.
 - 5. Provide all manufactured system components from a single source and by a single manufacturer.
 - 6. Provide components listed and labeled by ITS (DIR) or UL (DIR) for the type of system required and for use with the other components of the system.
- B. Engineered System Design Criteria:
 - 1. Provide total flooding of fire extinguishing agent at manufacturer's recommended concentration by volume and initiated within 10 of automated fire detection or immediately upon manual station operation, supplied continuously for 10 minutes with 10 percent allowance for room leakage.
 - 2. Direct discharge parallel to ceiling; use 360 degree pattern nozzles except where obstructions would make 360 distribution inefficient.
 - 3. Provide sufficient amount of fire extinguishing agent. Consider the following when computing volume:
 - a. Volume of protected area.
 - b. Specific volume of fire extinguishing agent.
 - c. Additional quantities of fire extinguishing agent required to compensate for openings, pipe losses.
 - d. Other special conditions affecting extinguishing agent concentration.

2.2 FIRE SUPPRESSION SYSTEM CONTROL PANEL

- A. Provide system controller in the form of fire alarm system monitored, self-contained control panel or module.
- B. Type: Combination type approved as both alarm and releasing device, with solid state internal circuitry enclosed in NEMA IA 10030, Type 1 cabinet.
- C. Provide NFPA 72, Class A circuit supervision for wire break or ground faults of:
 - 1. Zone detection loops.
 - 2. Suppression system solenoid valves.
 - 3. Power supply and circuit wiring and fuse.
 - 4. Battery interconnecting wires and fuse.
 - 5. Alarm in abort mode.
- D. Conceal control switches and indicators, with exception of Power On, Master Trouble, Supervisory Trouble, Circuit 1 Alarm, Circuit 2 Alarm and Release Indicators.
- E. Equip panel with following standard features:
 - 1. Visual and audible annunciation of trouble or alarm signals.
 - 2. Panel reset switch.
 - 3. Trouble alarm silence switch with ring back feature.
 - 4. Battery test meter and switch.
 - 5. Manual discharge switch.
 - 6. Deadman abort switch.
 - 7. Programmable timers for pre-discharge and discharge, 0 to 60 second cycle.
 - 8. Isolated relay contactors for external alarm or equipment and ventilation shutdown.
 - 9. Relay contactors for general trouble signal.
 - 10. Relay contactor activated by detector zone board in alarm or trouble mode.
- F. Annunciation: Provide the following annunciation:
 - 1. Power On: Green.
 - 2. System Trouble: Amber.
 - 3. Battery Trouble: Amber.
 - 4. Ground Fault: Amber.
 - 5. Release trouble: Amber.
 - 6. Agent Release: Red.
 - 7. Alarm Output Trouble: Amber.
 - 8. Supervisory Trouble: Amber.
- G. Batteries: Provide nickel cadmium batteries and charger for continuous operation of detection, alarm, actuation and supervision functions for 24 hours. Provide automatic battery switch-over upon failure of primary power supply.
- H. BAS, BMS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet IP.
- I. Initiating Devices:
 - 1. Manual Pull Stations:
 - a. Semi-flush housing fitted with double action control fitted with "push in" tab and "pull down" lever that locks in position after releasing spring-loaded contact switch,

for mounting on electrical outlet box; addressable using manufacturer's standard monitor module.

- 1) Activate all audible and visual alarms.
 - 2) Override any abort station or time delay function.
 - 3) Activate all release and shutdown functions normally triggered by detectors or alarm system.
 - 4) Engraved Sign or Label: Provide adjacent to each manual release station indicating area protected and that actuation will cause discharge of fire extinguishing agent.
2. Manual System Abort Switch:
 - a. Stainless steel plate with momentary contact push button, countdown timer, magnetic door holders manual release, for mounting on electrical outlet box; addressable using manufacturer's standard monitor module.
 - b. Engraved Sign or Label: Provide adjacent to each manual abort station, indicating area protected and that actuation will prevent discharge of fire extinguishing agent after automatic system is activated.

J. Notification and Control Devices:

1. Alarm Bells: 24 VDC with supervision of circuit wiring, of modular design, red baked enamel finish, with minimum sound level of 84 dba at 10 feet (3 m), for mounting on 4 inch (100 mm) electrical outlet box.
2. Alarm Horns: 24 VDC with supervision of circuit wiring, with minimum sound level of 90 dba at 10 feet (3 meters), for mounting on 4 inch (100 mm) electrical outlet box.
3. Strobe Beacon: 24 VDC with system identification on strobe lens.

K. Fire-Suppression Operating Sequence:

1. Actuation of one detector in either zone circuit:
 - a. Illuminate zone indicator.
 - b. Energize alarm bell.
 - c. Shut down air-conditioning system and close dampers.
 - d. Close doors to area.
 - e. Signal building fire alarm system.
2. Actuation of second detector on second zone circuit:
 - a. Illuminate zone indicator.
 - b. Energize alarm horn.
 - c. Shut down power to protected equipment.
 - d. Actuate time delay for up to 30 seconds.
 - e. Release extinguishing agent into protected area.
 - f. If abort switch is engaged, delay release.
 - g. Upon abort switch disengagement release extinguishing agent unless system cleared and reset.
3. Discharge of Extinguishing Agent:
 - a. Sounds alarm bells and horns.
 - b. Operates strobes.

2.3 SPACE OR AREA SIGNAGE

- A. Entrance Warning Sign: One warning sign at each entrance to protected area.
- B. Exit Warning Signs: One lighted, flashing warning sign at each exit from protected area.

2.4 SYSTEM PIPING AND SPECIALTIES

- A. Steel Pipe: ASTM A53/A53M or ASTM A106/A106M Schedule 40, or ASTM A135/A135M Schedule 10, galvanized as specified in ASTM A53/A53M.
 - 1. Fittings: ASME B16.3 malleable iron class 300 for sizes 2 inch (50 mm) and smaller, or ASTM A234/A234M, wrought steel welding type fittings.
- B. Pipe Hangers: ASME B31.1, UL (DIR) approved listing for sprinkler systems, split clamp up to 2-1/2 inch (60 mm) size, riser clamps over 2-1/2 inch (60 mm) size, adequate to offset discharge thrust.
- C. Escutcheons: Chrome plated pressed or stamped brass, one-piece or split pattern, minimum 2 inches (50 mm) larger than opening.
- D. Gauges: ASME B40.100, UL 393, or UL 404; 3-1/2 inch (9 mm) in diameter cast aluminum case, phosphor bronze bourdon tube, rotary brass movement, brass socket, front re-calibration adjustment, black figures on white background, 1 percent mid-scale accuracy, scale calibrated in psi.

2.5 CLEAN-AGENT CONTAINERS

- A. Containers:
 - 1. Steel, red enamel finish; standard model and size for ease of replacement and addition.
 - 2. Where multiple, replaceable containers are used, provide only containers of the same size and holding the same amount of extinguishing agent.
- B. Contents: Fill with required fire extinguishing agent.
- C. Identification: Permanent plate or marking, specifying agent, tare and gross weight, pounds of fire extinguishing agent, and pressurization level; installed so plate or marking is visible and readable.
- D. Safety Release: Equip with frangible disc safety device.
- E. Valves: Heavy duty forged brass, with safety pressure relief device, manual control, discharge valve, and pressure gauge.
- F. Pressure Gauge: Visual indicator of internal pressure.
- G. Low Pressure Switch: Electronic sensor; reports to control panel and provides audible and visual alarms when container pressure drops below 230 psi (1586 kPa).
- H. Manifold: Provide for systems with more than one container, with rack to secure each and check valves between each discharge and manifold.

2.6 AGENT DISCHARGE NOZZLES

- A. Nozzles: UL (DIR) listed; orifice size providing required rates of discharge and coverage and to distribute extinguishing agent uniformly throughout protected area.

- B. Construction: Two-piece chrome plated brass or aluminum nozzle with textured finish with female pipe thread integral on body; one-piece deflector plate.
- C. Identification: Permanently mark nozzles with manufacturer's part number, UL listing and equivalent single orifice diameter.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that enclosing walls are continuous above ceilings and below raised floors to enable required concentration to be built up and maintained for required time to ensure fire is extinguished.

3.2 INSTALLATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe. Remove scale and dirt on inside and outside before assembly. Blow out pipe before nozzles or discharge devices are installed.
- B. Route piping in orderly manner, concealed, plumb and parallel to building structure, and maintain gradient. Install piping to conserve building space, and not interfere with use of space and other work.
- C. Securely support piping in accordance with ASME B31.1 with allowance for fire extinguishing agent thrust forces, and thermal expansion and contraction.
- D. Use grooved mechanical couplings and fasteners only in accessible locations. Roll groove piping only.
- E. Install unions downstream of valves and at equipment or apparatus connections.
- F. Identify in accordance with requirements of referenced standard.
 - 1. Place directional arrows and system labels wherever piping changes direction and minimum 20 feet (6 m) on straight runs.
- G. Containers: Mount and anchor as indicated on drawings.
- H. Install wiring in compliance with NFPA 70, see Section 260583.
- I. At hazard area walls pack space between pipe, pipe sleeve, or surface penetration with mineral fiber with elastomer caulk to a depth of 1/2 inch (13 mm). Provide escutcheons where exposed piping passes through walls, floors, and ceilings. Seal pipe penetrations of fire separations. See Section 078400.
- J. Locate discharge nozzle approximately 6 inches (150 mm) above or below ceiling and 6 inches (150 mm) below raised floors. Avoid interference with other piping and equipment.
- K. Locate remote manual releases at one or more doors to protect area where indicated. Locate deadman abort switch adjacent.

- L. Mounting Height of Notification Devices: Between 72 to 80 inches (86.5 to 203.2 cm) above finished floor.
- M. Locate extinguishing agent supply and backup supply in each protected area.
- N. Locate manual release at each exit from protected area.
- O. Locate strobe units at points of entrance to each protected area.
- P. Locate abort station at points of exit from each protected area.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer Services: Provide experienced manufacturer's field engineer to supervise installation and performance testing of the system.
- B. Perform field inspection and testing in accordance with Section 014000 - Quality Requirements.
- C. Test distribution piping and valving, prior to nozzle installation, to 50 psi (340 kPa) air pressure test. Inspect joints using soap water solution or halide torch or lamp. Repair leaks and retest. Maintain test pressure for four hours.
- D. Upon completion of installation provide final checkout inspection by factory trained representative of manufacturer to ascertain proper system operation. Leave system in a fully commissioned and automatic readiness state with circuitry energized and supervised.
- E. Test circuits including automatic discharge, manual discharge, equipment shut-down, alarm devices, and storage container pressure. Test supervision of each circuit.
- F. Check each ionization detector with a sensitivity meter, adjust. Record sensitivity, and include record in test report.
- G. Submit original copies of tests, indicating that factory trained technical representatives of the manufacturer have inspected and tested systems and are satisfied with methods of installation, connections and operation.
- H. Pressure test entire enclosure with test fan, pressurizing protected area both under positive and negative conditions. Confirm that leakage is within system design allowance.

END OF SECTION 212200

SECTION 213000 - FIRE PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. End-suction fire pump.
- B. Electric motor drive.
- C. Jockey pump.

1.2 RELATED REQUIREMENTS

- A. Section 210500 - Common Work Results for Fire Suppression: Fire protection piping.
- B. Section 210513 - Common Motor Requirements for Fire Suppression Equipment.
- C. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.
- D. Section 284600 - Fire Detection and Alarm.

1.3 REFERENCE STANDARDS

- A. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- B. NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NFPA 20 - Standard for the Installation of Stationary Pumps for Fire Protection; 2025.
- D. UL (DIR) - Online Certifications Directory; Current Edition.
- E. UL 448 - Centrifugal Stationary Pumps for Fire-Protection Service; Current Edition, Including All Revisions.
- F. UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.
- G. UL 1478 - Fire Pump Relief Valves; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers literature including general assembly, pump curves showing performance characteristics with pump and system, operating point indicated, NPSH curve, controls, wiring diagrams, and service connections.

- C. Shop Drawings: Indicate layout, general assembly, components, dimensions, weights, clearances, and methods of assembly.
- D. Certificates: Certify that fire pumps meet or exceed specified requirements at specified operating conditions and that the installation complies with regulatory requirements. Submit summary and results of shop tests performed in accordance with NFPA 20
- E. Test Reports: Indicate results of hydrostatic test and field acceptance tests.
- F. Manufacturer's Instructions: Indicate support details, connection requirements, for fire pump system.
- G. Designer's Qualification Statement.
- H. Manufacturer's Qualification Statement.
- I. Installer's Qualification Statement.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 13 and NFPA 20; where requirements differ comply with the most stringent.
- B. Provide certificate of compliance from authority have jurisdiction indicating approval of field acceptance tests.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fire pumps and components in factory packing. Comply with manufacturer's rigging and installation instructions.
- B. Protect fire pumps and components from physical damage including effects of weather, water, and construction debris.
- C. Provide temporary inlet and outlet caps, and maintain in place until installation.

PART 2 PRODUCTS

2.1 FIRE PUMPS

- A. End-Suction Fire Pump:
 - 1. UL 448 and UL 778; horizontal-end-suction, single-stage centrifugal pump for maximum working pressure of 186 psi (1,282 kPa).
 - 2. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
 - 3. Impeller: Bronze double suction fully enclosed, balanced and keyed to shaft.
 - 4. Bearings: Grease lubricated ball bearings, replaceable without opening casing.
 - 5. Shaft: Alloy steel with replaceable bronze shaft sleeve.
 - 6. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F (110 degrees C) maximum continuous operating temperature.

7. Drive: Flexible coupling with coupling guard.
8. Baseplate: Cast iron or fabricated steel with integral drain rim.

2.2 ELECTRIC MOTOR DRIVE:

- A. Motor: Squirrel cage induction type, NEMA MG 00001; in open drip-proof NEMA EN 10250 enclosure, 3,500 rpm; see Section 210513.
- B. Controller: Limited service type with auto-transformer starter, in NEMA EN 10250 enclosure, including the following:
 1. Disconnect Switch: Externally operable, quick break type.
 2. Circuit Breaker: Comply with NFPA 20; minimum 65,000 amperes interrupting capacity.
 3. Motor Starter: Energized automatically through pressure switch or manually by externally operable handle.
 4. Pressure Switch: Set to cut in at _____ psi (_____ kPa).
 5. Pilot Lamp: Indicates circuit breaker closed and power available.
 6. Test Accessories: Ammeter test link and voltmeter test studs.
 7. Alarm Relay: Energizes alarm to indicate circuit breaker open or power failure.
 8. Switch Relay: For remote start.
 9. Manual Selector Station: On enclosure marked "Automatic" and "Non-Automatic".

2.3 JOCKEY PUMP

- A. Electrically operated, horizontal or vertical, single or multi stage, turbine type centrifugal pump with standard open drip-proof horizontal motor.
- B. Control by automatic jockey pump controller with full voltage starter and minimum run timer to start pump on pressure drop in system and stay in operation for minimum period of time. Fire pump shall start automatically on further pressure drop or on jockey pump failure.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NFPA 20.
- B. Provide access space around pumps for service; no less than minimum as recommended by manufacturer.
- C. Piping: Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For base mounted pumps, provide supports under elbows on pump suction and discharge; see Section 210500.
- D. Provide drains for bases and seals, piped to and discharging into floor drains.
- E. Provide for connection to electrical service; see Section 260583.
- F. Lubricate pumps before start-up.
- G. Check, align, and certify pumps by qualified installer prior to start-up.

- H. Provide supervisory alarm notifications using auxiliary dry contacts interconnected into fire alarm system for monitoring by Owner-designated central or off-site point of constant attendance; see Section 284600.

3.2 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements for additional requirements.
- B. Perform hydrostatic tests, flushing, and field acceptance tests as specified in NFPA 20.

END OF SECTION 213000

SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Motors.
2. Packless expansion joints.
3. Alignment guides and anchors.
4. Sleeves without waterstop.
5. Sleeves with waterstop.
6. Stack-sleeve fittings.
7. Sleeve-seal systems.
8. Grout.
9. Silicone sealants.
10. Escutcheons.
11. Thermometers and Thermowells, lead free.
12. Pressure gauges, dial type, and gauge attachments, lead free.
13. Test plugs, lead free.

B. Related Requirements:

1. Section 221119 "Domestic Water Piping Specialties" for water meters.
2. Section 331415 "Site Water Distribution Piping" for domestic water meters outside the building.
3. Division 07 Sections for penetration firestopping and waterproofing coordination.
4. Division 26 Sections for motor controllers and electrical coordination.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product, excluding motors which are included in Part 1 of the plumbing equipment Sections.
 - a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
 - b. Include operating characteristics and furnished accessories.
 - c. Include manufacturer installation requirements.

B. Delegated Design Submittals: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.

4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Sustainable Design Submittals:

1. Provide documentation demonstrating compliance of sealants with applicable environmental and VOC requirements where required by Division 01.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of expansion joint, gauge, and accessories provided under this Section, for inclusion in operation and maintenance manuals.

1.5 COORDINATION

- A. Coordinate installation of motors, equipment, and accessory devices with the following:
1. Electrical characteristics, controllers, and available power with Division 26.
 2. Penetrations, sleeves, and seals with structural, architectural, and waterproofing systems.
 3. Supports, anchors, and piping layout with building construction and clearance requirements.
 4. Environmental conditions of installation locations, including exposure to moisture, corrosion, and temperature.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Products intended to convey or dispense water for human consumption shall comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, temperatures, installation environments.
- C. Capability: Provide products and installations capable of accommodating maximum axial, lateral, and angular movement as scheduled or indicated on Drawings.
- D. Corrosion Resistance: Products installed in exterior environments or areas exposed to moisture shall be corrosion resistant or protected with coatings suitable for the installation environment.

2.2 MOTORS

A. Motor Requirements, General:

1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
3. Comply with NEMA MG 1 unless otherwise indicated.
4. Motors furnished as part of equipment assemblies shall be provided by the equipment manufacturer.
5. Motors installed in humid, exterior, or corrosive environments shall be suitable for the installation conditions.

B. Motor Characteristics:

1. Duty: Continuous duty suitable for the operating conditions of the connected equipment.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads without exceeding the motor manufacturer's rated capacity

C. Motor Types and Construction:

1. Motors shall be suitable for the type of service required by the connected equipment and compatible with the power supply provided.
2. Polyphase motors shall be induction type unless otherwise required by equipment manufacturers.
3. Single-phase motors shall be manufacturer's standard type suitable for the application.
4. Motors shall have antifriction bearings suitable for radial and thrust loads imposed by the driven equipment.
5. Provide totally enclosed fan-cooled (TEFC) enclosures unless otherwise required by the equipment manufacturer or installation conditions.
6. Motors operated with variable frequency drives shall be inverter-duty rated and compatible with the drive manufacturer's requirements.
7. Motors shall include internal thermal protection or shall be protected by external overload devices provided with motor controllers.
8. Minimum service factor shall be 1.15.
9. Coordinate motor electrical characteristics with Division 26.

2.3 EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

A. Performance Requirements:

1. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Provide products and installations that will accommodate required thermal movement without overstressing piping or connected equipment.

B. Packless Expansion Joints:

1. Rubber Union Connector Expansion Joints, Lead Free:

- a. Source Limitations: Obtain expansion joints from manufacturer regularly engaged in production of similar products..
 - b. Material: Twin reinforced EPDM rubber spheres with external restraining cables.
 - c. Minimum Pressure Rating: Not less than the piping system design pressure, unless otherwise indicated.
 - d. End Connections for Compatible with piping system materials and joining methods.
 - e. End Fittings: Manufacturer's standard materials suitable for the application.
 2. Flexible-Hose Packless Expansion Joints, Lead Free:
 - a. Source Limitations: Obtain expansion joints from manufacturer regularly engaged in production of similar products.
 - b. Description: Manufactured flexible-hose assemblies with corrugated metal inner hose and braided outer sheath with end fittings compatible with piping system materials.
 - c. Construction: Stainless steel hose and braid with end connections suitable for the service and installation conditions.
 - d. Pressure Rating: Not less than the piping system design pressure unless otherwise indicated.
 - e. End Connections: Compatible with piping system materials and joining methods.
- C. Alignment Guides and Anchors:
1. Alignment Guides:
 - a. Source Limitations: Obtain alignment guides from single manufacturer regularly engaged in production of similar products.
 - b. Description: Steel, factory-fabricated alignment guide designed to control lateral movement of piping and maintain alignment through expansion devices. Provide dielectric spacer for use with copper tubing/piping.
 2. Anchor Materials:
 - a. Steel Shapes and Plates: ASTM A36/A36M.
 - b. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
 - c. Washers: ASTM F844, steel, plain, flat washers.
 - d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened concrete, with tension and shear capacities appropriate for application.
 - 1) Stud: Threaded, Stainless steel.
 - 2) Expansion Plug: Stainless steel.
 - 3) Washer and Nut: Stainless steel.

2.4 SLEEVES AND SLEEVE SEALS

- A. Sleeves without Waterstop:
1. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.
 2. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
 3. Steel Sheet Sleeves: ASTM A653/A653M, 24 gauge minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.

4. PVC Pipe Sleeves: ASTM D1785, Schedule 40.
- B. Sleeves with Waterstop:
 1. Description: Manufactured steel or galvanized-steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.
- C. Stack-Sleeve Fittings:
 1. Description: Manufactured, galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with setscrews.
- D. Sleeve-Seal Systems:
 1. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - a. Hydrostatic Seal: 20 psig minimum.
 - b. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - c. Pressure Plates: Stainless steel.
 - d. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.
- E. Grout:
 1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
 2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
 3. Design Mix: 5000 psi, 28-day compressive strength.
 4. Packaging: Premixed and factory packaged.
- F. Silicone Sealants:
 1. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
 - a. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.
 2. Silicone Sealant, S, P, T, NT: Single-component, 25, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant.
 - a. Standard: ASTM C920, Type S, Grade P, Class 25, Uses T and NT.
 3. Silicone Foam Sealant: Multicomponent, silicone-based liquid elastomers that expand and cure in place to produce a flexible, nonshrinking foam.
 4. Sustainable Design Requirements:

- a. Sealants shall comply with low-emitting material requirements of the project and applicable LEED rating system.
- b. Provide sealants with VOC content not exceeding limits established by SCAQMD Rule 1168 or applicable local regulations.
- c. Provide documentation required to demonstrate compliance with LEED credits, including product data and VOC content certification.

2.5 ESCUTCHEONS

A. Escutcheon Types:

1. One-Piece, Steel Type: With polished stainless steel finish and setscrew fastener.
2. One-Piece, Stainless Steel Type: With polished stainless steel finish.
3. One-Piece, Cast-Brass Type: With polished stainless steel finish and setscrew fastener.
4. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.
5. One-Piece, Stamped-Steel Type: With polished stainless steel finish and spring-clip fasteners.
6. Split-Plate, Stamped-Steel Type: With polished stainless steel finish; concealed hinge; and spring-clip fasteners.

B. Floor Plates:

1. Split Floor Plates: Stainless steel with concealed hinge.

2.6 METERS AND GAUGES FOR PLUMBING PIPING

A. Thermometers, Lead Free:

1. Standard: ASME B40.200 for analog devices.
2. Case: Sealed type, stainless steel; 3-inch nominal diameter minimum.
3. Dial (Analog): Nonreflective aluminum with permanent scale markings in deg F and deg C.
4. Sensor: Stainless steel or Lead-free brass compatible with thermowell
5. Display: Analog dial or digital, as indicated.
6. Window: Glass or acrylic plastic.
7. Accuracy:
 - a. Analog: Plus or minus 1 percent of span.
 - b. Digital: Plus or minus 1 deg F (0.5 deg C).
8. Fluids: Mercury-free.
 - a. Design for Thermowell Installation: Bare stem.

B. Thermowells, Lead Free:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: Lead-free copper or stainless steel.
4. Material for Use with Steel Piping: Type 316 stainless steel .
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: **NPS 1/2, NPS 3/4, or NPS 1**, or as required to match threaded opening in pipe.

7. Internal Threads: Size and thread type as required to match thermometer mounting threads.
 8. Bore: Diameter required to match thermometer bulb or stem.
 9. Insertion Length: Length to extend to center of pipe.
 10. Lagging Extension: Include on thermowells for insulated piping and tubing. Extension is to be of sufficient length to extend beyond finished insulation surface.
 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
 12. Heat-Transfer Medium: Mixture of graphite and glycerin.
- C. Pressure Gauges, Dial Type, Lead Free - Direct Mounted, Metal Case:
1. Standard: ASME B40.100.
 2. Case: Liquid-filled Sealed type; cast aluminum or drawn steel 4-1/2-inch nominal diameter.
 3. Pressure-Element Assembly: Lead-free Bourdon tube.
 4. Pressure Connection: Lead-free brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless otherwise indicated.
 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 6. Dial: Nonreflective aluminum with permanent scale markings graduated in psi and kPa.
 7. Pointer: Dark-colored metal.
 8. Window: Glass or acrylic plastic.
 9. Accuracy: Grade B, plus or minus 2 percent of middle half of span.
- D. Gauge Attachments, Lead Free:
1. Snubbers: ASME B40.100, lead-free brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.
 2. Valves: Lead-free brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.
- E. Test Plugs, Lead Free:
1. Description: Test-station fitting made for insertion into piping tee fitting.
 2. Body: Lead-free brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
 3. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
 4. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
 5. Core Inserts: EPDM self-sealing rubber.
- F. Test-Plug Kits, Lead Free:
1. Furnish one test-plug kit containing one thermometer, one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes are to be of diameter to fit test plugs and of length to project into piping.
 2. Low-Range Thermometer, Lead Free: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range is to be at least 25 to 125 deg F.
 3. High-Range Thermometer, Lead Free: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range is to be at least 0 to 220 deg F.
 4. Pressure Gauge, Lead Free: Small, lead-free Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range is to be at least 0 to 200 psig.
 5. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 2-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 3. Using nonshrink grout, seal the space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES WITH WATERSTOP

- A. Install sleeve with waterstop as new walls and slabs are constructed.
- B. Using grout, seal space around outside of sleeves. Select to maintain fire resistance of floor/slab/wall.

3.3 INSTALLATION OF STACK-SLEEVE FITTINGS

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide **1/4-inch** annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to **2 inches** above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.5 INSTALLATION OF ESCUTCHEONS

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

3.6 INSTALLATION OF METERS AND GAUGES

- A. Install thermometer with thermowell at each required thermometer location.
- B. Install thermowells in vertical position in piping tees.
- C. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- D. Install thermowells with extension on insulated piping.
- E. Fill thermowells with heat-transfer medium.
- F. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- G. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at most readable position.
- H. Install test plugs in piping tees.

- I. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlets and outlets of each domestic water heat exchanger.
 - 3. Inlet and outlet of each domestic hot-water storage tank.
 - 4. Inlet and outlet of each remote domestic water chiller.
 - 5. Outlet side of hot-water-balancing valve.
 - 6. Each main hot-water-recirculating line return pipe.
- J. Install pressure gauges in the following locations:
 - 1. Building water service entrance into building.
 - 2. Inlet and outlet of each pressure-reducing valve.
 - 3. Suction and discharge of each domestic water pump.

3.7 CONNECTIONS

- A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

3.8 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gauges to proper angle for best visibility.

3.9 FIELD QUALITY CONTROL

- A. Sleeves and Sleeve Seals:
 - 1. Perform the following tests and inspections:
 - a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
 - b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
 - 2. Prepare test and inspection reports.
- B. Escutcheons:
 - 1. Using new materials, replace broken and damaged escutcheons and floor plates.

3.10 SLEEVES APPLICATION

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above and below Grade:
 - a. Sleeves -seal systems.

- 1) Select sleeve size to allow for 2-inch annular clear space between piping and sleeve for installing sleeve-seal system.
2. Concrete Slabs-on-Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for 2-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
 - a. Sleeves with waterstops.
4. Interior Wall and Partitions:
 - a. Sleeves without waterstops.

3.11 ESCUTCHEONS APPLICATION

- A. Escutcheons for New Piping and Relocated Existing Piping:
 1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 2. Chrome-Plated Piping: One piece, stainless steel with polished stainless steel with polished, chrome-plated finish.
 3. Insulated Piping:
 - a. One piece, steel with [polished, chrome-plated] [polished brass] finish.
 - b. One piece, stainless steel with polished stainless steel finish.
 - c. One piece, cast brass with [polished, chrome-plated] [polished brass] finish.
 - d. One piece, stamped steel [or split plate, stamped steel with concealed hinge] [or split plate, stamped steel with exposed-rivet hinge] with polished, chrome-plated finish.
 4. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a. One piece, stainless steel with polished stainless steel finish.
 5. Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a. One piece, stainless steel with polished stainless steel finish. polished.
 6. Bare Piping in Unfinished Service Spaces:
 - a. One piece, stainless steel with polished stainless steel finish. polished.
 7. Bare Piping in Equipment Rooms:
 - a. One piece, stainless steel with polished stainless steel finish. Polished.
- B. Escutcheons for Existing Piping to Remain:

1. Chrome-Plated Piping: Split plate, stainless steel with concealed hinge with polished, stainless steel finish.
 2. Insulated Piping: Split plate, stainless steel with concealed hinge with polished stainless steel finish
 3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split plate, stainless steel with concealed hinge with polished stainless steel finish.
 4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split plate, stainless steel with concealed hinge with polished stainless steel finish.
 5. Bare Piping in Unfinished Service Spaces: Split plate, stainless steel with concealed hinge with polished stainless steel finish.
 6. Bare Piping in Equipment Rooms: Split plate, stainless steel with concealed hinge with polished stainless steel finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
1. New Piping and Relocated Existing Piping: One piece, floor plate.
 2. Existing Piping: Split floor plate.

END OF SECTION 220500

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.
 - 4. Gate valves.
 - 5. Chainwheels.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer.
- C. FKM: Fluoroelastomer.
- D. NBR: Nitrile butadiene rubber (also known as Buna-N).
- E. NRS: Nonrising stem.
- F. OS&Y: Outside screw and yoke.
- G. PTFE: Polytetrafluoroethylene.
- H. RPTFE: Reinforced polytetrafluoroethylene.
- I. RS: Rising stem.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include material descriptions and dimensions of individual components.
 - b. Include operating characteristics and furnished accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
 3. Set ball valves open to minimize exposure of functional surfaces.
 4. Set butterfly valves closed or slightly open.
 5. Block check valves in either closed or open position.
 6. Set gate valves closed to prevent rattling.
- B. Use the following precautions during storage:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Standards:
1. Domestic-water piping valves intended to convey or dispense water for human consumption must comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372; or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.5 for flanges on steel valves.
 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 5. ASME B16.18 for cast-copper solder-joint connections.
 6. ASME B16.22 for wrought-copper solder-joint connections.
 7. ASME B16.34 for flanged- and threaded-end connections.
 8. ASME B16.51 for press joint connections.
 9. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Bypass and Drain Connections: MSS SP-45.
- H. Valve Actuator Type:
 - 1. Gear Actuator: For quarter-turn ball valves **NPS 4** and larger.
 - 2. Hand Lever: For quarter-turn ball valves smaller than **NPS 4**.
- I. Valves in Insulated Piping:
 - 1. Provide stem extensions sized to project through full insulation thickness and finish, minimum 2 inches **2-inches**.
 - 2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 - 3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 BALL VALVES, LEAD FREE

- A. Ball Valves, Lead Free, Threaded or Soldered Ends - Brass, Two Piece with Full Port:
 - 1. Standards: MSS SP-110 and MSS SP-145.
 - 2. CWP Rating: **600 psig**.
 - 3. Body Design: Two piece.
 - 4. Body Material: Forged brass, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 - 5. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 - 6. Seats: PTFE.
 - 7. Stem: Stainless steel, blowout-proof.
 - 8. Ball: Stainless steel, vented (self-relieving).
 - 9. Port: Full.
- B. Ball Valves, Lead Free, Press Ends - Brass, Two Piece with Full Port, Stainless Ball and Stem:
 - 1. Standards: MSS SP-110, MSS SP-145, and IAPMO/ANSI Z1157.
 - 2. CWP Rating: Minimum **200 psig**.
 - 3. Body Design: Two piece.
 - 4. Body Material: Forged brass, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 - 5. Ends: Press.
 - 6. Press-End Connections Rating: Minimum **200 psig**.
 - 7. Seats: PTFE or RPTFE.
 - 8. Stem: Stainless steel, blowout-proof.
 - 9. Ball: Stainless steel, vented (self-relieving).
 - 10. Port: Full.
 - 11. O-Ring Seal: NBR or EPDM.
 - 12. Press ends shall be compatible with the piping system manufacturer's press tools and fittings.
- C. Ball Valves, Lead Free, Threaded or Soldered Ends - Brass, Three Piece with Full Port and Brass Trim:

1. Standards: MSS SP-110 and MSS SP-145.
 2. CWP Rating: **600 psig.**
 3. Body Design: Three piece.
 4. Body Material: Forged brass, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 5. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 6. Seats: PTFE.
 7. Stem: Brass.
 8. Ball: Chrome-plated brass.
 9. Port: Full.
- D. Ball Valves, Lead Free, Threaded or Soldered Ends - Brass, Three Piece with Full Port and Stainless Steel Trim:
1. Standards: MSS SP-110 and MSS SP-145.
 2. CWP Rating: **600 psig.**
 3. Body Design: Three piece.
 4. Body Material: Forged brass, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 5. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 6. Seats: PTFE.
 7. Stem: Stainless steel.
 8. Ball: Stainless steel, vented.
 9. Port: Full.
- E. Ball Valves, Lead Free, Threaded or Soldered Ends - Bronze, Two Piece with Full Port and Bronze or Brass Trim:
1. Standards: MSS SP-110 and MSS SP-145.
 2. CWP Rating: **600 psig.**
 3. Body Design: Two piece.
 4. Body Material: Bronze, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 5. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 6. Seats: PTFE.
 7. Stem: Bronze or brass.
 8. Ball: Chrome-plated brass.
 9. Port: Full.
- F. Ball Valves, Lead Free, Press Ends - Bronze, Two Piece with Full Port and Bronze or Brass Trim:
1. Standards: MSS SP-110, MSS SP-145, and IAPMO/ANSI Z1157.
 2. CWP Rating: Minimum **200 psig.**
 3. Body Design: Two piece.
 4. Body Material: Bronze, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 5. Ends: Press.
 6. Press-End Connections Rating: Minimum **200 psig.**
 7. Seats: PTFE or RPTFE (reinforced PTFE).
 8. Stem: Bronze or brass.
 9. Ball: Chrome-plated brass.
 10. Port: Full.
 11. O-Ring Seal: EPDM or NBR.
 12. Press ends shall be compatible with the piping system manufacturer's press tools and fittings.

- G. Ball Valves, Lead Free, Threaded or Soldered Ends - Bronze, Two Piece with Full Port and Stainless Steel Trim:
1. Standards: MSS SP-110 and MSS SP-145.
 2. CWP Rating: 600 psig.
 3. Body Design: Two piece.
 4. Body Material: Bronze, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 5. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
 6. Seats: PTFE.
 7. Stem: Stainless steel, blowout-proof.
 8. Ball: Stainless steel, vented (self-relieving).
 9. Port: Full.
- H. Ball Valves, Lead Free, Flanged or Threaded Ends - Steel, with Full Port, Class 150:
1. Standards: MSS SP-72 and MSS SP-110.
 2. CWP Rating: 285 psig.
 3. Body Design: Split body.
 4. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
 5. Ends: Flanged or threaded. See Part 3 ball valve schedule articles.
 6. Seats: PTFE.
 7. Stem: Stainless steel.
 8. Ball: Stainless steel, vented (self-relieving).
 9. Port: Full.

2.4 BUTTERFLY VALVES, LEAD FREE

- A. Butterfly Valves, Lead Free, Single Flange (Lug Type) - Iron, with Ductile-Iron Disc:
1. Standard: MSS SP-67, Type I.
 2. CWP Rating: 150 psig, or 200 psig. See Part 3 butterfly valve schedule articles.
 3. Body Design: Single flange (lug type), suitable for bidirectional service at rated pressure without use of downstream flange.
 4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 5. Seat: EPDM suitable for potable water service or NBR. See Part 3 butterfly valve schedule articles.
 6. Stem: One- or two-piece stainless steel, blowout-resistant.
 7. Disc: Nickel-plated or epoxy-coated ductile iron.
- B. Butterfly Valves, Lead Free, Flangeless (Wafer Type) - Iron, with Ductile-Iron Disc:
1. Standard: MSS SP-67, Type I.
 2. CWP Rating: 150 psig or 200 psig. See Part 3 butterfly valve schedule articles.
 3. Body Design: Flangeless (wafer type), suitable for bidirectional service at rated pressure.
 4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron, Lead Free (NSF/ANSI 61 and NSF/ANSI 372).
 5. Seat: EPDM suitable for potable water service or NBR. See Part 3 butterfly valve schedule articles.
 6. Stem: One- or two-piece stainless steel, blowout-resistant.
 7. Disc: Nickel-plated or epoxy-coated ductile iron.

2.5 CHECK VALVES, LEAD FREE

- A. Check Valves, Lead Free, Swing Type, Threaded or Soldered Ends - Bronze, with Bronze Disc, Class 125:
1. Standard: MSS SP-80, Type 3.
 2. CWP Rating: 200 psig.
 3. Body Design: Horizontal flow.
 4. Body Material: ASTM B62, bronze.
 5. Ends: Threaded or soldered. See Part 3 check valve schedule articles.
 6. Disc: Bronze, renewable seat design.
- B. Check Valves, Lead Free, Swing Type, Threaded or Soldered Ends - Bronze, with Bronze Disc, Class 150:
1. Standard: MSS SP-80, Type 3.
 2. CWP Rating: 300 psig.
 3. Body Design: Horizontal flow.
 4. Body Material: ASTM B62, bronze.
 5. Ends: Threaded or soldered. See Part 3 check valve schedule articles.
 6. Disc: Bronze, renewable seat design.
- C. Check Valves, Lead Free, Swing Type, Press Ends - Bronze:
1. Standards: MSS SP-80 and MSS SP-139.
 2. CWP Rating: Minimum 200 psig.
 3. Body Design: Horizontal flow.
 4. Body Material: ASTM B584, bronze.
 5. Ends: Press.
 6. Press-End Connections Rating: Minimum 200 psig.
 7. Disc: Bronze.
- D. Check Valves, Lead Free, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 125:
1. Standard: MSS SP-125.
 2. CWP Rating: 200 psig.
 3. Body Material: ASTM A126, gray iron.
 4. Style: Compact wafer, spring loaded.
 5. Seat: Bronze or stainless steel.
- E. Check Valves, Lead Free, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 150:
1. Standard: MSS SP-125.
 2. CWP Rating: 300 psig.
 3. Body Material: ASTM A395/A395M or ASTM A536, ductile iron, Body epoxy coated and lead-free compliance.
 4. Style: Compact wafer, spring loaded.
 5. Seat: Bronze or stainless steel.
- F. Check Valves, Lead Free, Center Guided - Iron, Compact Wafer, with Resilient Seat, Class 125:
1. Standard: MSS SP-125.
 2. CWP Rating: 200 psig.
 3. Body Material: ASTM A126, gray iron.

4. Style: Compact wafer, spring loaded.
 5. Seat: EPDM suitable for potable water service.
- G. Check Valves, Lead Free, Center Guided - Iron, Compact Wafer, with Resilient Seat, Class 150:
1. Standard: MSS SP-125.
 2. CWP Rating: 300 psig.
 3. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
 4. Style: Compact wafer, spring loaded.
 5. Seat: EPDM suitable for potable water service.
- H. Check Valves, Lead Free, Dual-Plate Type - Iron, with Metal Seat, Class 125:
1. Standard: API 594.
 2. CWP Rating: 200 psig.
 3. Body Design: Wafer, spring-loaded plates.
 4. Body Material: ASTM A126, gray iron, epoxy coated, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 5. Seat: Bronze or stainless steel..
- I. Check Valves, Lead Free, Dual-Plate Type - Iron, with Metal Seat, Class 150:
1. Standard: API 594.
 2. CWP Rating: 300 psig.
 3. Body Design: Wafer, spring-loaded plates.
 4. Body Material: ASTM A395/A395M or ASTM A536, ductile iron, epoxy coated, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 5. Seat: Bronze or stainless steel..

2.6 GATE VALVES, LEAD FREE

- A. Gate Valves, Lead Free, Threaded or Soldered Ends - Bronze, NRS, Class 125:
1. Standard: MSS SP-80, Type 1.
 2. CWP Rating: 200 psig.
 3. Body Material: Bronze with integral seat and screw-in bonnet, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 4. Ends: Threaded or solder joint. See Part 3 gate valve schedule articles.
 5. Stem: Bronze or silicon bronze.
 6. Disc: Solid wedge, bronze.
 7. Packing: Asbestos free.
 8. Handwheel: Malleable iron.
- B. Gate Valves, Lead Free, Threaded or Soldered Ends - Bronze, RS, Class 125:
1. Standard: MSS SP-80, Type 2.
 2. CWP Rating: 200 psig.
 3. Body Material: Bronze with integral seat and screw-in bonnet, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 4. Ends: Threaded or solder joint. See Part 3 gate valve schedule articles.
 5. Stem: Bronze or silicon bronze.
 6. Disc: Solid wedge, bronze.
 7. Packing: Asbestos free.

8. Handwheel: Malleable iron.
- C. Gate Valves, Lead Free, Threaded Ends - Bronze, NRS, Class 150:
1. Standard: MSS SP-80, Type 1.
 2. CWP Rating: 300 psig.
 3. Body Material: Bronze with integral seat and union-ring bonnet, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 4. Ends: Threaded.
 5. Stem: Bronze or silicon bronze.
 6. Disc: Solid wedge, bronze.
 7. Packing: Asbestos free.
 8. Handwheel: Malleable iron.
- D. Gate Valves, Lead Free, Threaded Ends - Bronze, RS, Class 150:
1. Standard: MSS SP-80, Type 2.
 2. CWP Rating: 300 psig.
 3. Body Material: Bronze with integral seat and union-ring bonnet, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 4. Ends: Threaded.
 5. Stem: Bronze or silicon bronze.
 6. Disc: Solid wedge, bronze.
 7. Packing: Asbestos free.
 8. Handwheel: Malleable iron.
- E. Gate Valves, Lead Free, Press Ends - Bronze:
1. Standards: MSS SP-80 and MSS SP-139.
 2. CWP Rating: Minimum 200 psig.
 3. Body Material: Bronze with integral seat and union-ring bonnet, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 4. Ends: Press.
 5. Press Ends Connection Rating: Minimum 200 psig.
 6. Stem: Brass or bronze, RS or NRS.
 7. Disc: Solid wedge, bronze.
 8. Packing: Graphite or PTFE.
 9. Port: Full.
 10. Handwheel: Malleable iron, bronze, or aluminum.
- F. Gate Valves, Lead Free, Flanged Ends - Iron, NRS, Class 125:
1. Standard: MSS SP-70, Type I.
 2. CWP Rating: 200 psig.
 3. Body Material: Gray iron with bolted bonnet, epoxy coated interior and exterior, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
 4. Ends: Flanged.
 5. Trim: Bronze, renewable seat design.
 6. Disc: Solid wedge.
 7. Packing and Gasket: Asbestos free.
- G. Gate Valves, Lead Free, Flanged Ends - Iron, OS&Y, Class 125:
1. Standard: MSS SP-70, Type I.

2. CWP Rating: 200 psig.
3. Body Material: Gray iron with bolted bonnet, epoxy coated interior and exterior, lead-free compliant (NSF/ANSI 61 and NSF/ANSI 372).
4. Ends: Flanged.
5. Trim: Bronze, renewable seat design.
6. Disc: Solid wedge.
7. Packing and Gasket: Asbestos free.

2.7 CHAINWHEELS

- A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.
 1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. factory epoxy coating.
 2. Chain: Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Examine press fittings to verify they have been properly pressed.
- F. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.

- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.
- H. Chainwheels: Install chainwheels on manual operators for **NPS 4** and larger and more than **96 inches** above floor. Extend chains to **60 inches** above finished floor.
- I. Install check valves for proper direction of flow and as follows:
 - 1. Check Valves: Center-guided and plate type, in horizontal or vertical position, between flanges.
 - 2. Check Valves, Swing Type: In horizontal position with hinge pin level.
 - 3. Check Valves, Lift Type: With stem upright and plumb.
- J. Valve Tags: Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
- K. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's written recommended maximum.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.
 - 7. Wafer-Type Valves: Install between companion flanges.
 - 8. Press-end valves: Press ends shall be compatible with the piping system manufacturer's press tools and fittings

3.5 DOMESTIC HOT- AND COLD-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Ball valves, lead free, two-piece, full port, brass body with stainless steel ball and stem, PTFE seats and seals.
 - a. End Connections: Press or solder to match piping system.
 - b. Pressure Rating: Minimum 600 W
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Ball valves, lead free, flanged ductile iron or steel body, full port, stainless steel ball, PTFE seats.
 - a. End Connections: Flanged.
 - b. Pressure Class: Class 150.

3.6 DOMESTIC HOT- AND COLD-WATER BUTTERFLY VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Butterfly valves, lead free, ductile iron body, aluminum-bronze or stainless steel disc, EPDM seat.
 - a. End Connections: Grooved, lug, or wafer to match piping system.
 - b. Pressure Rating: 200 psi CWP minimum.

3.7 DOMESTIC HOT- AND COLD-WATER CHECK VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Check valves, lead free, swing type, threaded or soldered ends - bronze, with bronze disc, Class 125.
 - 2. Check valves, lead free, swing type, press ends - bronze.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Check valves, lead free, center guided - spring-loaded silent type, ductile iron body with resilient seat, Class 125 or 150.
 - a. End Connections: Flanged or wafer to match piping system.
 - b. Seat Material: EPDM

3.8 PUMP-DISCHARGE CHECK VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Check valves, lead free, swing type, threaded or soldered ends - bronze, with bronze disc, Class 125.
- B. Pipe NPS 2-1/2 (DN 65) and Larger for Domestic Water Pumps:
 - 1. Check valves, lead free, center guided - spring-loaded silent type, ductile iron body with resilient seat, Class 125 or 150.
 - a. End Connections: Flanged or wafer to match piping system.

- b. Seat Material: EPDM.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports - metal.
2. Pipe hangers - metal, trapeze type.
3. Strut support system - metal, rod type.
4. Thermal hanger shield inserts.
5. Fastener systems.
6. Pipe-positioning systems.
7. Equipment supports.

B. Related Requirements:

1. Section 220500 "Common Work Results for Plumbing" for pipe guides and anchors.
2. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal strut support systems.
3. Rooftop-mounted strut support systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated Design Submittals: For trapeze hangers and strut support systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication/assembly and design calculations for trapeze hangers metal strut support systems.
2. Detail fabrication/assembly and design calculations for each type of strut support system, by the manufacturer's technical representative.

1.3 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze hangers, metal strut support systems, and equipment supports.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment are to withstand the effects of gravity loads and stresses within limits and under conditions indicated in accordance with ASCE/SEI 7 as adopted by the Florida Building Code.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 PIPE HANGERS AND SUPPORTS - METAL

- A. Pipe Hangers and Supports - Carbon Steel:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: hot-dip galvanized after fabrication.
 - 3. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 4. Hanger Rods: Continuous-thread rod, nuts, and washer made of **carbon steel**, hot-dip galvanized.
- B. Pipe/Tube Hangers and Supports - Copper:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-plated-steel, factory-fabricated components.
 - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of **carbon steel**, hot-dip galvanized.

2.3 PIPE HANGERS - METAL, TRAPEZE TYPE

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts. All components shall be hot-dip galvanized after fabrication.

2.4 STRUT SUPPORT SYSTEMS - METAL

- A. Strut Support System - Metal, Rod Type:

1. Description: Factory-fabricated pipe-support assembly, made of steel channels, vertical metal support rods, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
3. Struts: Continuous slotted carbon-steel channel with inturned lips.
4. Strut Width: Selected for applicable load criteria.
5. Strut Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel, hot-dip galvanized.
7. Metallic Coating: Hot-dip galvanized.

2.5 THERMAL HANGER SHIELD INSERTS

A. Thermal Hanger Shield Inserts:

1. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with **100 psig** minimum compressive strength and vapor barrier.
2. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with **100 psig** minimum compressive strength.
3. For Trapeze or Clamped Systems: Insert and shield are to cover entire circumference of pipe.
4. For Clevis or Band Hangers: Insert and shield are to cover bottom 180 degrees of pipe.
5. Insert Length: Extend **2 inches** beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- ### A. Fastener System - Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities required for supported loads and building materials where used.
- ### B. Fastener System - Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities required for supported loads and building materials where used.
1. Indoor Applications: Zinc-plated steel.
 2. Outdoor Applications: Stainless steel.

2.7 EQUIPMENT SUPPORTS

- ### A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes conforming to ASTM A36 and hot-dip galvanized after fabrication.

2.8 MATERIALS

- ### A. Aluminum: **ASTM B221** (**ASTM B221M**).
- ### B. Carbon Steel: ASTM A1011/A1011M.

- C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000 psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- 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 is to include weight of supported components plus 200 lb.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- B. Install lateral bracing with pipe hangers and supports to prevent swaying.
- C. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger. Coordinate location of concrete inserts before concrete is placed.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- F. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Thermal hanger shield inserts may be used. Include steel weight-distribution plate for pipe **NPS 4** and larger if pipe is installed on rollers.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields are to span an arc of 180 degrees.
 - a. Thermal hanger shield inserts may be used. Include steel weight-distribution plate for pipe **NPS 4** and larger if pipe is installed on rollers.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): **12 inches** long and **0.048 inch** thick.
 - b. NPS 4 : **12 inches** long and **0.06 inch** thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): **18 inches** long and **0.06 inch** thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): **24 inches** long and **0.075 inch** thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): **24 inches** long and **0.105 inch** thick.
 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- G. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- H. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 2. Field fabricate in accordance with ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- I. Thermal Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- J. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than **4 inches** thick after concrete is placed and cured. Use installers that are licensed by powder-actuated tool manufacturer.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners in accordance with manufacturer's written instructions.
 3. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
 4. Install fasteners in accordance with manufacturer's written instructions.
 5. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- K. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

- L. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- M. Equipment Support Installation:
 - 1. Fabricate from welded-structural-steel shapes.
 - 2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 - 3. Grouting: Place grout under supports for floor-mounted equipment, and make bearing surface smooth.
 - 4. Provide lateral bracing, to prevent swaying.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to **1-1/2 inches**.

3.5 PAINTING

- A. Touchup:
 - 1. Clean field welds and abraded, shop-painted areas. Repair damaged galvanized surfaces in accordance with ASTM A780.
 - 2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use thermal hanger shield inserts for insulated piping and tubing.
- F. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal Hanger Shield Inserts: For supporting insulated pipe.

END OF SECTION 220529

SECTION 220548.13 - VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Elastomeric isolation pads.
 - 2. Elastomeric isolation mounts.
 - 3. Restrained elastomeric isolation mounts.
 - 4. Open-spring isolators.
 - 5. Housed-spring isolators.
 - 6. Restrained-spring isolators.
 - 7. Housed-restrained-spring isolators.
 - 8. Pipe-riser resilient support.
 - 9. Resilient pipe guides.
 - 10. Elastomeric hangers.
 - 11. Spring hangers.
 - 12. Vibration isolation equipment bases.
- B. Related Requirements:
 - 1. Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
 - 2. Section 230548.13 "Vibration Controls for HVAC" for devices for HVAC equipment and systems.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
 - 3. Annotate to indicate application of each product submitted and compliance with requirements.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports for vibration isolation devices and equipment bases.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For vibration isolation equipment bases to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - 2. Size: Factory or field cut to match requirements of supported equipment.
 - 3. Minimum deflection as indicated on Drawings.
 - 4. Pad Material: Oil- and water-resistant rubber.

2.2 ELASTOMERIC ISOLATION MOUNTS

- A. Elastomeric Isolation Mounts:
 - 1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
 - 2. Minimum deflection as indicated on Drawings.
 - 3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

- A. Restrained Elastomeric Isolation Mounts:
 - 1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.
 - 2. Minimum deflection as indicated on Drawings.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to **500 psi**.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
7. Minimum deflection as indicated on Drawings.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Minimum deflection as indicated on Drawings.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi**.
 - b. Top housing with **threaded mounting holes and internal leveling device**.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi**.
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the 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 as indicated on Drawings.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
 1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with **adjustable** snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to **500 psi**.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the 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 as indicated on Drawings.

2.8 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum **1/2-inch**- Thick Neoprene:
 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 2. Maximum Load Per Support: **500 psi** on isolation material providing equal isolation in all directions.
 3. Minimum deflection as indicated on Drawings.

2.9 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum **1/2-inch**- Thick Neoprene:
 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 VIBRATION ISOLATION EQUIPMENT BASES

- A. Steel Rails: Factory-fabricated, welded, structural-steel rails.
 1. Design Requirements: Lowest possible mounting height with not less than **1-inch** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

- a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- B. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Concrete Inertia Base: Welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than **1-inch** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of 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 Pipe Supports: Secure pipes to trapeze member with clamps approved for application and suitable for the supported piping system.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static forces within specified loading limits.

3.3 INSTALLATION OF VIBRATION-CONTROL DEVICES

- A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules, where indicated on Drawings, or where the Specifications indicate they are to be installed on specific equipment and systems.
- B. Coordinate 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."
- C. Installation of vibration isolators must not cause any stresses, misalignment or change of position of equipment or piping.
- D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- E. Equipment Restraints:
 - 1. Install snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
- F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- G. 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.
- H. Where packaged equipment is factory-mounted on vibration isolation devices or integral inertia bases, field-installed isolation devices shall not be provided unless specifically indicated on Drawings. Coordinate installation requirements with equipment manufacturer.

3.4 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

- A. Coordinate 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. Coordinate dimensions of steel equipment rails, bases, and concrete inertia bases, with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate actual isolated equipment.

3.5 ADJUSTING

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height.
After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 220548.13

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Warning tape.
 - 4. Pipe labels.
 - 5. Stencils.
 - 6. Valve tags.
 - 7. Warning tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve-numbering scheme.
- E. Valve Schedules: For each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, stainless steel, aluminum, or anodized aluminum, **0.032-inch** minimum thickness, with predrilled or stamped holes for attachment hardware.
 - 2. Letter and Background Color: As indicated for specific application under Part 3.
 - 3. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch**.
 - 4. Minimum Letter Size: **1/4 inch** for name of units if viewing distance is less than **24 inches**, **1/2 inch** for viewing distances of up to **72 inches**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 5. Fasteners: Stainless steel rivets or self-tapping screws.
 - 6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- B. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/16 inch** thick, with predrilled holes for attachment hardware.
 - 2. Letter and Background Color: As indicated for specific application under Part 3.
 - 3. Maximum Temperature: Able to withstand temperatures of up to **160 deg F**.
 - 4. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch**.
 - 5. Minimum Letter Size: **1/4 inch** for name of units if viewing distance is less than **24 inches**, **1/2 inch** for viewing distances of up to **72 inches**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 6. Fasteners: Stainless steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/16 inch** thick, with predrilled holes for attachment hardware.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Maximum Temperature: Able to withstand temperatures of up to **160 deg F**.
- D. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch**.
- E. Minimum Letter Size: **1/4 inch** for name of units if viewing distance is less than **24 inches**, **1/2 inch** for viewing distances of up to **72 inches**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- F. Fasteners: Stainless steel rivets or self-tapping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA 70E.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

- A. Material: Vinyl.
- B. Minimum Thickness: **0.005 inch**.
- C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

- D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.
- E. Maximum Temperature: 160 deg F.
- F. Minimum Width: 4 inches.

2.4 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.5 STENCILS

- A. Stencils for Piping:
 - 1. Lettering Size: Size letters in accordance with ASME A13.1 for piping.
 - 2. Stencil Material: Aluminum, brass, or fiberboard.
 - 3. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 4. Identification Paint: Exterior, acrylic enamel in colors in accordance with ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 5. Letter and Background Color: As indicated for specific application under Part 3.

2.6 VALVE TAGS

- A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, stainless steel, aluminum, or anodized aluminum, 0.032-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass beaded chain.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or

space), normal operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Include valve-tag schedule in operation and maintenance data.

2.7 WARNING TAGS

- A. Description: Preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 1. Size: Approximately 4 by 7 inches.
 2. Fasteners: Reinforced grommet and wire or string.
 3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Letter and Background Color: As indicated for specific application under Part 3.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

- A. Permanently fasten labels on each item of plumbing equipment.
- B. Sign and Label Colors.
 1. White letters on an ANSI Z535.1 safety-green background.
- C. Locate equipment labels where accessible and visible.
- D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where hazard exists in accordance with requirements of OSHA and NFPA 70E.

3.4 INSTALLATION OF WARNING TAPE

- A. Warning Tape Color and Pattern: Yellow background with black diagonal stripes.
- B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than 6 ft. of clearance.
- C. Locate tape so as to be readily visible from the point of normal approach.

3.5 INSTALLATION OF PIPE LABELS

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- C. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1 on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- D. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. of each valve and control device.
 - 2. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 3. Within 3 ft. of equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping and equipment.
- E. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- F. Flow-Direction Arrows: Use arrows, in compliance with ASME A13.1, to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- G. Pipe-Label Color Schedule:
 - 1. Domestic Cold-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 - 2. Domestic Hot-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 - 3. Domestic Hot-Water Return Piping: White letters on an ANSI Z535.1 safety-green background.
 - 4. Sanitary Waste and Storm Drainage Piping: White letters on a black background.

3.6 INSTALLATION OF VALVE TAGS

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering

hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.

- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:

1. Valve-Tag Size and Shape:

- a. Domestic Cold Water: 2 inches, round.
- b. Domestic Hot Water: 2 inches, round.
- c. Domestic Hot-Water Return: 2 inches, round.
- d. Nonpotable Cold Water: 2 inches, round.
- e. Nonpotable Hot Water: 2 inches, round.
- f. Nonpotable Hot-Water Return: 2 inches, round.

2. Valve-Tag Colors:

- a. For each piping system, use the same lettering and background coloring system on valve tags as used in the piping system labels and background.

3.7 INSTALLATION OF WARNING TAGS

- A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.
- B. Attach warning tags, with proper message, to equipment and other items as required.

END OF SECTION 220553

SECTION 220593 - TESTING, ADJUSTING, AND BALANCING FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work of this Section Includes:
 - 1. TAB of domestic water system.
 - 2. TAB of plumbing equipment:
 - a. Domestic water booster pumps.
 - b. Domestic hot-water in-line circulation pumps.
 - 3. Pipe-leakage test verification.
- B. Related Requirements:
 - 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for TAB of HVAC.

1.2 DEFINITIONS

- A. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

1.3 INFORMATIONAL SUBMITTALS

- A. Sample report forms.
- B. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration and calibration interval.

1.4 QUALITY ASSURANCE

- A. Code and Authorities Having Jurisdiction Compliance: Furnish TAB services that comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents and approved submittals to become familiar with domestic water system and booster pump requirements.
- B. Verify installed domestic water systems and booster pump assemblies are complete and ready for testing.
- C. Examine approved submittals for plumbing systems and equipment.
- D. Examine system and equipment installations, and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- E. Observe demonstration of operating safety interlocks and controls on plumbing equipment.
- F. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PROCEDURES FOR DOMESTIC WATER SYSTEMS

- A. Prepare test reports for pumps and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Cross-check the summation of required equipment flow rates with system design flow rates.
- B. Prepare domestic water systems for testing and balancing as follows:
 - 1. Check expansion tank for proper setting.
 - 2. Check water heater for proper discharge temperature setting.
 - 3. Check remotest point of outlet for adequate pressure.
 - 4. Check flow-control valves for proper position.
 - 5. Check that air has been purged from the system.
- C. Measure and record upstream and downstream pressure of pressure-reducing valves.
- D. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- E. Check settings and operation of each safety valve. Record settings.

3.3 PROCEDURES FOR DOMESTIC WATER SYSTEM BOOSTER PUMPS

- A. Adjust pumps to deliver total design flow.
 - 1. Measure total water flow.

- a. Measure flow by main flow meter, if installed.
 - b. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
4. Verify pump operation through full range of variable-frequency drive control and confirm maintenance of scheduled discharge pressure at varying demand conditions.

3.4 PROCEDURES FOR DOMESTIC HOT-WATER CIRCULATING INLINE PUMP

- A. Adjust pump to deliver total design flow.
 1. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
 2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
 3. Verify final system conditions as follows:
 - a. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.

END OF SECTION 220593

SECTION 220716 - PLUMBING EQUIPMENT INSULATION

GENERAL

1.1 SUMMARY

- A. Section includes insulating the following plumbing equipment that is not factory insulated:
 - 1. Domestic water, hot-water and cold-water pumps.
- B. Related Sections:
 - 1. Section 220719 "Plumbing Piping Insulation."

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings: Submit insulation layout details only where required for large field-fabricated removable insulation assemblies.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Insulation shall be installed by experienced mechanics regularly engaged in mechanical insulation work.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Deliver insulation materials to the Project site in unopened containers labeled with manufacturer, product type, and size.

1.5 COORDINATION

- A. Coordinate Insulation with supports, hangers, and equipment clearances to maintain required access and serviceability.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. All insulation installed indoors and outdoors shall have a flame-spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E84.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Domestic Water Boiler Breeching Insulation Schedule" and "Indoor Equipment Insulation Schedule" articles for where insulating materials are to be applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
- C. Glass-Fiber and Mineral Wool, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.4 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
- C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
- D. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 - 1. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
 - 2. Wet Flash Point: Below 0 deg F.
 - 3. Service Temperature Range: 40 to 200 deg F.
 - 4. Color: Black color.

- E. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- F. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.5 MASTICS AND COATINGS

- A. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: **Minus 20 to plus 180 deg F.**
 - 3. Color: White.
- B. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: **0 to 180 deg F.**
- C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: **Minus 50 to plus 220 deg F.**
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Water-Vapor Permeance: ASTM E96/E96M, greater than **1.0 perm**at manufacturer's recommended dry film thickness.
 - 2. Service Temperature Range: **Minus 20 to plus 180 deg F.**
 - 3. Color: White.

2.6 LAGGING ADHESIVES

- A. Lagging Adhesives: Comply with MIL-A-3316C, Class I, Grade A, and be compatible with insulation materials, jackets, and substrates.
 - 1. Service Temperature Range: **0 to plus 180 deg F.**
 - 2. Color: White.

2.7 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant.
 - 2. Service Temperature Range: **Minus 40 to plus 250 deg F.**

3. Color: White or gray.
- C. FSK and Metal Jacket Flashing Sealants:
1. Fire- and water-resistant, flexible, elastomeric sealant.
 2. Service Temperature Range: **Minus 40 to plus 250 deg F.**
 3. Color: Aluminum.
- D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Fire- and water-resistant, flexible, elastomeric sealant.
 2. Service Temperature Range: **Minus 40 to plus 250 deg F.**
 3. Color: White.

2.8 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: White.
 3. Factory-fabricated tank heads and tank side panels.
- D. Metal Jacket:
1. Aluminum Jacket: Comply with **ASTM B209**, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Finish and thickness are indicated in field-applied jacket schedules.
 - b. Moisture Barrier for Indoor Applications:
 - c. Moisture Barrier for Outdoor Applications:
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.

- 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
- 3) Tee covers.
- 4) Flange and union covers.
- 5) End caps.
- 6) Beveled collars.
- 7) Valve covers.
- 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

- E. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.
- F. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 4 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.
- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

2.11 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.12 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
- 1.
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
- 1.
 2. Width: 3 inch .
 3. Thickness: 6.5 mils .
 4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.
 6. Tensile Strength: **40 lbf/inch** in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
- 1.
 2. Width: **2 inches** .
 3. Thickness: **6 mils** .
 4. Adhesion: **64 ounces force/inch** in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: **18 lbf/inch** in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
- 1.
 2. Width: **2 inches** .
 3. Thickness: **3.7 mils** .
 4. Adhesion: **100 ounces force/inch** in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: **34 lbf/inch** in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
- 1.
 2. Width: **3 inches** .
 3. Film Thickness: **6 mils** .
 4. Adhesive Thickness: **1.5 mils** .
 5. Elongation at Break: 145 percent.
 6. Tensile Strength: **55 psi** in width.
- F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
- 1.
 2. Width: **3 inches** .
 3. Film Thickness: **6 mils** .
 4. Adhesive Thickness: **1.5 mils** .
 5. Elongation at Break: 145 percent.
 6. Tensile Strength: **55 psi** in width.

2.13 SECUREMENTS

- A. Bands:
1. Wing seals are primarily used for fastening bands together. Closed seals are occasionally used for large, 84-inch- (2130-mm-) diameter applications and where fastening bands are used with springs. Wing seals are reusable; closed seals are not.
 2. Stainless Steel: ASTM A240/A240M, Type 304; **0.015 inch** thick, **1/2 inch** wide with wing seal.
 3. Aluminum: **ASTM B209**, Alloy 3003, 3005, 3105, or 5005; Temper H-14, **0.020 inch** thick, **1/2 inch** wide with wing seal.

4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.
- B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel fully annealed, 0.106-inch-diameter shank; length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - b. Spindle: Nylon, 0.106-inch- diameter shank; length to suit depth of insulation indicated, up to 2-1/2 inches.
 - c. Adhesive: Recommended by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel Aluminum Stainless steel, fully annealed; 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, galvanized steel.

2.14 CORNER ANGLES

- A. PVC Corner Angles: 30-mils thick, minimum 1- by 1-inch PVC in accordance with ASTM D1784, Class 16354-C, white or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040-inch thick, minimum 1- by 1-inch, aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless Steel Corner Angles: 0.024-inch thick, minimum 1- by 1-inch stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

END OF SECTION 220716

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Sanitary waste piping where insulation is indicated on Drawings or required for condensation control.
 - 5. Storm-water piping where insulation is indicated on Drawings or required for condensation control.
 - 6. Roof drains and rainwater leaders.
 - 7. Supplies and drains for handicap-accessible lavatories and sinks.
 - 8. Domestic water and storm piping installed at exterior locations and within the open parking garage where insulation is indicated on Drawings or required for condensation control.
- B. Related Sections:
 - 1. Section 220716 "Plumbing Equipment Insulation" for equipment insulation.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Sustainable Design Submittals:
 - 1. Product data indicating recycled content for insulation materials where applicable.
 - 2. VOC content documentation for adhesives, mastics, coatings, and sealants in accordance with LEED requirements and applicable South Coast Air Quality Management District (SCAQMD) limits.
 - 3. Manufacturer certification that insulation products do not contain CFCs or HCFCs
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at pipe expansion joints for each type of insulation.
 - 3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 4. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 5. Detail application of field-applied jackets.
 - 6. Detail application at linkages of control devices.

- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 2. Jacket Materials for Pipe: 12 inches long by NPS 2.
 3. Sheet Jacket Materials: 12 inches square.
 4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
1. Piping Mockups:
 - a. One 10-foot section of NPS 2 straight pipe.
 - b. One each of a 90-degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.
 - d. One NPS 2 or smaller valve and one NPS 2-1/2 or larger valve.
 - e. Four support hangers, including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.
 - j. One union.
 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 4. Obtain Architect's approval of mockups before starting insulation application.
 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 7. Demolish and remove mockups when directed.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of the manufacturer, fabricator, type, description, and size.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.

- C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
 - 1. Preformed Pipe Insulation, Type II, Class 1: Unfaced.
 - 2. Preformed Pipe Insulation, Type II, Class 2: With factory-applied ASJ jacket.
 - 3. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between **minus 70 deg F** and **220 deg F**. Comply with ASTM C534/C534M, Type I for tubular materials.
- H. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to **850 deg F** in accordance with ASTM C411. Comply with ASTM C547.
 - 1. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ+ jacket.
 - 2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral Wool, Preformed Pipe: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to **1200 deg F** in accordance with ASTM C447. Comply with ASTM C547.
 - 1. Preformed Pipe Insulation: Type II, Grade A with factory-applied ASJ+ jacket.
 - 2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
- J. Phenolic: Fabricated pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C1126, Type III.
 - 1. Pre-fabricated Pipe Insulation: Type III with factory-applied ASJ+ jacket.
 - 2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C534/C534M or ASTM C1427, Type I, Grade 1, for tubular materials.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.

- C. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.4 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of **minus 100 to plus 200 deg F**.
 - 1. Adhesive shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 - 1. Adhesive shall comply with LEED low-emitting materials requirements and applicable VOC limits.
 - 2. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
 - 3. Wet Flash Point: Below **0 deg F**.
 - 4. Service Temperature Range: **40 to 200 deg F**.
 - 5. Color: Black.
- D. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Adhesive shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- E. Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of **minus 75 to plus 300 deg F**.
 - 1. Adhesive shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- F. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
 - 1. Adhesive shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.5 MASTICS AND COATINGS

- A. Materials are compatible with insulation materials, jackets, and substrates.
 - 1. Mastics and coatings shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: **Minus 20 to plus 180 deg F**.
 - 3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
 - 4. Color: White.

- C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: 0 to 180 deg F.
 - 3. Color: White.
- D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
 - 3. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1.
 - 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Color: White .

2.6 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 58 to plus 176 deg F.
 - 3. Color: White or gray.
 - 4. Sealants shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- C. FSK and Metal Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 3. Color: Aluminum.
 - 4. Sealants shall comply with LEED low-emitting materials requirements and applicable VOC limits.
- D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 3. Color: White.
 - 4. Sealants shall comply with LEED low-emitting materials requirements and applicable VOC limits.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136 Types I, II, III, IV, and VII.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: White.
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- C. Metal Jacket:
1. Aluminum Jacket: Comply with **ASTM B209**, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **3-mil-** thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: **3-mil-** thick polysurlyn.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 2. Stainless Steel Jacket: ASTM A240/A240M.

- a. Factory cut and rolled to size.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **3-mil-** thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: **3-mil-** thick polysurlyn.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- D. Underground Direct-Buried Jacket: **125-mil-** thick vapor barrier and waterproofing membrane, consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately **2 oz./sq. yd.** with a thread count of **10 strands by 10 strands/sq. in.** for covering pipe and pipe fittings.
- B. Woven Polyester Mesh: Approximately **1 oz./sq. yd.** with a thread count of **10 strands by 10 strands/sq. in.**, in a Leno weave, for pipe.

2.10 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of **8 oz./sq. yd.**

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1.
 - 2. Width: **3 inches.**
 - 3. Thickness: **11.5 mils.**
 - 4. Adhesion: **90 ounces force/inch** in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: **40 lbf/inch** in width.
 - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 - 1.

2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
- 1.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
- 1.
 2. Width: 2 inches.
 3. Thickness: 3.7 mils.
 4. Adhesion: 100 ounces force/inch in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

- A. Bands:
1. Stainless Steel: ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with closed seal.
 2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with closed seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.
- D. Protective Shielding Piping Enclosures:
1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer **5 mils** thick and an epoxy finish **5 mils** thick if operating in a temperature range of between **140 and 300 deg F**. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 2. Carbon Steel: Coat carbon steel operating at a service temperature of between **32 and 300 deg F** with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 2. Cover circumferential joints with **3-inch-** wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced **4 inches** o.c.
 3. Overlap jacket longitudinal seams at least **1-1/2 inches**. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at **4 inches** o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least **4 inches** beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least **2 inches** below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least **2 inches**.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and

- irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation conforms to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least **2 inches** over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at **6 inches** o.c.
4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch**, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at **6 inches** o.c.
4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch**, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless steel bands at 12-inch intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.11 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where PVC jackets are indicated, install with **1-inch** overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

- B. Where metal jackets are indicated, install with **2-inch** overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands **12 inches** o.c. and at end joints.

3.12 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Do not field paint aluminum or stainless steel jackets.

3.13 FIELD QUALITY CONTROL

- A. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- B. All insulation applications will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.14 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.15 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. All Pipe Sizes: Flexible Elastomeric, 1 inch thick.
- B. Domestic Hot and Recirculated Hot Water:
 - 1. **All Pipe Sizes: Glass-Fiber, Preformed Pipe Insulation, Type I, with factory-applied ASJ+ jacket. Thickness:**
 - a. Up to 1-1/4 inch: 1 inch thick
 - b. 1-1/2 inch and larger: 1-1/2 inches.

- C. Stormwater and Overflow:
 - 1. All Pipe Sizes: Flexible Elastomeric: 1 inch thick.
- D. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Flexible Elastomeric: 1 inch thick.

3.16 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Domestic Cold Water, Outdoor / Garage:
 - 1. All Pipe Sizes:
 - a. Flexible Elastomeric: 1 inches thick (for condensation control).
 - b. Field-applied jacket: Aluminum jacket with 3-mil polysurlyn moisture barrier.
- B. Storm piping, Outdoor / Garage :
 - 1. All Pipe Sizes: Flexible Elastomeric: 1 inch thick.
 - 2. Field-applied jacket: Aluminum jacket with 3-mil polysurlyn moisture barrier.

3.17 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Concealed:
 - 1. None.
- C. Piping, Exposed:
 - 1. None.

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Concealed:
 - 1. None.
 - 2. Aluminum, Stucco Embossed: 0.016 inch thick with 3-mil polysurlyn moisture barrier.
- C. Piping, Exposed:
 - 1. Aluminum, Stucco Embossed with Z-Shaped Locking Seam:
 - a. 0.020 inch thick minimum thickness with 3-mil polysurlyn moisture barrier.
 - b. 0.024 inch thick where piping is less than 10 feet above finished floor or subject to physical damage (open parking garage, service areas, accessible locations).

3.19 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 220719

SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:
 - 1. Domestic hot- and cold-water piping.
 - 2. Sanitary waste and vent piping.
 - 3. Storm drainage piping.
 - 4. Plumbing pumps.
 - 5. Plumbing equipment.
- B. Related Requirements:
 - 1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- B. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- C. IAPMO: International Association of Plumbing and Mechanical Officials.
- D. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For plumbing testing technician.
- B. Construction Checklists:
 - 1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 019113 "General Commissioning Requirements." Contractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning Requirements" and to resolve any issues with the CxA.
 - 2. Cx plan, including material, installation, and performance construction checklists for systems, assemblies, subsystems, equipment, and components relating to plumbing to be part of the Cx process and in accordance with requirements in Section 019113 "General Commissioning Requirements".

- C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Contractor, provide the following:
1. Equipment/instrument identification number.
 2. Planned Cx application or use.
 3. Manufacturer, make, model, and serial number.
 4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 QUALITY ASSURANCE

- A. Plumbing Testing Technician Qualifications: Technicians to perform plumbing Construction Checklist verification tests. Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
1. Journey level or equivalent skill level with knowledge of plumbing system, electrical concepts, and building operations.
 2. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. Testing Equipment and Instrumentation Quality and Calibration:
1. Capable of testing and measuring performance within the specified acceptance criteria.
 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- C. Proprietary Test Instrumentation and Tools:
1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Plumbing system proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS

- A. Perform Cx process for plumbing systems in accordance with Section 019113 "General Commissioning Requirements."

3.2 CONSTRUCTION CHECKLISTS

- A. Preliminary detailed construction checklists are to be prepared under Section 019113 "General Commissioning Requirements" for each plumbing system, assembly, subsystem, equipment, and component required to be commissioned. Contractor performs the following:
 - 1. Review plumbing preliminary construction checklists and provide written comments on Construction Checklist items where appropriate.
 - 2. Return preliminary Construction Checklist with review comments within **10** days of receipt.
 - 3. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 - 4. Use only construction checklists marked "Approved for Use, (date)." Mark construction checklists in the appropriate place, as indicated Project events are completed, and provide pertinent details and other information.
- B. Prepare preliminary detailed construction checklists for each plumbing system, assembly, subsystem, equipment, and component required to be commissioned.
 - 1. Submit preliminary construction checklists to CxA and Designer for review.
 - 2. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 - 3. Use only construction checklists marked "Approved for Use, (date)." Mark construction checklists in the appropriate place as indicated Project events are completed, and provide pertinent details and other information.
- C. Additional Systems Required to Be Commissioned:
 - 1. Facility water-distribution piping, including the following:
 - a. Domestic water piping, fittings, and specialties outside the building.
 - b. Pumps, motors, accessories, and controls.
 - c. Outdoor water-storage tanks.
 - d. Sleeves and sleeve seals.
 - e. Meters and gauges.
 - f. General-duty and specialty valves.
 - g. Hangers and supports.
 - h. Vibration isolation.
 - 2. Domestic water piping, including the following:
 - a. Domestic cold- and hot-water piping, fittings, and specialties inside the building.

- b. Pumps, motors, accessories, and controls.
 - c. Sleeves and sleeve seals.
 - d. Indoor water-storage tanks.
 - e. Meters and gauges.
 - f. General-duty and specialty valves.
 - g. Hangers and supports.
 - h. Vibration isolation.
- 3. Sanitary waste and vent piping, including the following:
 - a. Gravity and forced-main sewerage piping, fittings, and specialties.
 - b. Sanitary waste interceptors.
 - c. Pumps, motors, accessories, and controls.
 - d. Drains.
 - e. Sleeves and sleeve seals.
 - f. Meters and gauges.
 - g. General-duty and specialty valves.
 - h. Hangers and supports.
 - i. Vibration isolation.
- 4. Storm-water piping, including the following:
 - a. Drainage piping, fittings, and specialties.
 - b. Pumps, motors, accessories, and controls.
 - c. Drains and collection basins.
 - d. Rainwater-collection and storage equipment.
 - e. Sleeves and sleeve seals.
 - f. Meters and gauges.
 - g. General-duty and specialty valves.
 - h. Hangers and supports.
 - i. Vibration isolation.
- 5. Plumbing fixtures, including the following:
 - a. Water closets, supports and connections, supplies, and flush valves.
 - b. Urinals, supports and connections, supplies, and flush valves.
 - c. Lavatories, supports, supplies, drain connections, and faucets.
 - d. Sinks, supports, supplies, drain connections, and faucets.
 - e. Showers, supplies, drain connections, and faucets.
 - f. Wash fountains, supplies, drain connections, and faucets.
 - g. Drinking fountains, supplies, and drainage connections.

3.3 Cx TESTING PREPARATION

- A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- B. Certify that plumbing system instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and that all systems are set to and maintaining set points as required by the design documents.

- C. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.5 Cx TESTS COMMON TO PLUMBING SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response compared to acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 22 Sections specifying plumbing systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

END OF SECTION 220800

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings - domestic water.
2. Ductile-iron pipe and fittings - domestic water.
3. Piping joining materials - domestic water.
4. Encasement for piping.
5. Transition fittings - domestic water.
6. Dielectric fittings - domestic water.

B. Related Requirements:

1. Section 331415 "Site Water Distribution Piping" for water-service piping **and water meters** outside the building from source to the point where water-service piping enters the building.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. System purging and disinfecting activities report.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Installers of pressure-sealed joints are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Domestic water piping, tubing, fittings, joints, and appurtenances intended for potable service shall comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372.

2.2 PIPING MATERIALS

- A. Potable-water piping and components shall comply with NSF 61 and NSF 372.

2.3 COPPER TUBE AND FITTINGS - DOMESTIC WATER

- A. Drawn-Temper Copper Tube: **ASTM B88, Type L for aboveground piping and Type K where installed below slab.**
- B. Annealed-Temper Copper Tube: **Type K ASTM B88.**
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- F. Cast Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- G. Wrought Copper Unions: ASME B16.22.
- H. Copper-Tube, Mechanically Formed Tee Fitting - Domestic Water: For forming T-branch on copper water tube.
 - 1. Description: Tee formed in copper tube in accordance with ASTM F2014.
- I. Grooved, Mechanical-Joint, Copper Tube Appurtenances - Domestic Water:
 - 1. Grooved-End, Copper Fittings: ASTM B75/B75M copper tube or ASTM B584 bronze castings.
 - 2. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting, EPDM-rubber gasket, UL classified per NSF 61 and NSF 372, and rated for minimum **180 deg F**, for use with ferrous housing and steel bolts and nuts; **300 psig** minimum CWP pressure rating.
- J. Pressure-Seal-Joint Fittings, Copper or Bronze - Domestic Water:
 - 1. Housing: Copper.
 - 2. O-Rings and Pipe Stops: EPDM.
 - 3. Tools: Manufacturer's special tools.
 - 4. Minimum **200 psig** working-pressure rating at **250 deg F**.

2.4 DUCTILE-IRON PIPE AND FITTINGS - DOMESTIC WATER

- A. Mechanical-Joint, Ductile-Iron Pipe:
 - 1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Standard-Pattern, Mechanical-Joint Fittings:
 - 1. AWWA C110/A21.10, ductile or gray iron.
 - 2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- C. Compact-Pattern, Mechanical-Joint Fittings:
 - 1. AWWA C153/A21.53, ductile iron.
 - 2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.5 PEX TUBE AND FITTINGS - DOMESTIC WATER

2.6 PIPING JOINING MATERIALS - DOMESTIC WATER

- A. Pipe-Flange Gasket Materials:
 - 1. AWWA C110/A21.10, rubber, flat face, **1/8 inch** thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
 - 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B32, lead-free alloys.
- D. Flux: ASTM B813, water flushable.
- E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.7 ENCASEMENT FOR PIPING

- A. Standard: ASTM A674 or AWWA C105/A21.5.
- B. Form: Sheet or tube.
- C. Color: Black.

2.8 TRANSITION FITTINGS - DOMESTIC WATER

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Sleeve-Type Transition Couplings - Domestic Water: AWWA C219.

2.9 DIELECTRIC FITTINGS - DOMESTIC WATER

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions - Domestic Water:
 - 1. Standard: ASSE 1079.
 - 2. Pressure Rating: **150 psig**.
 - 3. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges - Domestic Water:
 - 1. Standard: ASSE 1079.
 - 2. Factory-fabricated, bolted, companion-flange assembly.
 - 3. Pressure Rating: 150 **psig** minimum at **180 deg F**.
 - 4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits - Domestic Water:
 - 1. Nonconducting materials for field assembly of companion flanges.
 - 2. Pressure Rating: **150 psig**.
 - 3. Gasket: Phenolic, Temperature Rating: 180 **deg F**.
 - 4. Bolt Sleeves: Phenolic or polyethylene.
 - 5. Washers: Phenolic with steel backing washers.
- E. Dielectric Nipples - Domestic Water:
 - 1. Standard: IAPMO PS 66.
 - 2. Electroplated steel nipple complying with ASTM F1545.
 - 3. Pressure Rating and Temperature: 150 **psig**.
 - 4. End Connections: Male threaded or grooved.
 - 5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Under-building-slab, domestic water, building-service piping shall be mechanical-joint ductile-iron pipe with mechanical-joint fittings:
 - 1. Mechanical-joint, ductile-iron pipe; standard- or compact-pattern, mechanical-joint fittings; and mechanical joints.
- E. Aboveground domestic water piping, NPS 2 and smaller shall be drawn-temper copper tube, ASTM B88, Type L, with soldered or brazed joints or pressure-seal fittings.
 - 1. Drawn-temper copper tube, **ASTM B88, Type L**; cast- or wrought-copper, solder-joint fittings; and brazed or soldered joints.
 - 2. Drawn-temper copper tube, **ASTM B88, Type L**; copper pressure-seal-joint fittings; and pressure-sealed joints.
- F. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 , shall be drawn-temper copper tube, ASTM B88, Type L, with brazed joints or grooved copper appurtenances where indicated.
- G. Aboveground domestic water piping, NPS 5 to NPS 8 shall be drawn-temper copper tube, ASTM B88, Type L, with brazed joints or grooved copper appurtenances.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab for trap primer piping in accordance with CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints in accordance with AWWA C600 and AWWA M41.
- D. Install underground ductile-iron pipe in polyethylene encasement in accordance with ASTM A674 or AWWA C105/A21.5.

- E. Install valves in accordance with Section 220523 "General-Duty Valves for Plumbing Piping."
- F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."
- G. Install domestic water piping level and plumb. Provide drainage at low points where indicated.
- H. Rough-in domestic water piping for water-meter installation in accordance with utility company's requirements.
- I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- J. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- L. Install piping and valves with sufficient clearance to permit operation, maintenance, and replacement.
- M. Install nipples, unions, special fittings, and valves with pressure ratings equal to or greater than the system operating pressure.
- N. Install piping free of sags and bends.
- O. Install fittings for changes in direction and branch connections.
- P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- Q. Install pressure gauges on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gauges in Section 220500 "Common Work Results for Plumbing."
- R. Install aquastats in hot-water circulation piping. Comply with requirements for aquastats in Section 221123.21 "Inline, Domestic Water Pumps."
- S. Install thermometers on **inlet and** outlet piping from each water heater. Comply with requirements for thermometers in Section 220500 "Common Work Results for Plumbing."
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."

- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings in accordance with ASTM B828 or CDA's "Copper Tube Handbook."
- F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools and procedure recommended by pressure-seal-fitting manufacturer. Leave insertion marks on pipe after assembly.
- G. Extruded-Tee Connections: Form tee in copper tube in accordance with ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
- H. Joint Construction for Grooved-End Copper Tubing: Make joints in accordance with AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
- I. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts in accordance with ASME B31.9.
- J. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.5 INSTALLATION OF TRANSITION FITTINGS

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.

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2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.6 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric union or dielectric nipples.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange insulating kits.
- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.7 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Install hangers for copper and ductile iron tube and pipe, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- C. Support horizontal piping within **12 inches** of each fitting.
- D. Support vertical runs of copper and ductile iron tube and pipe to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.8 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
 2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for **NPS 2-1/2** and larger.

3.9 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

3.10 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 as applicable:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system in accordance with either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11 ADJUSTING

- A. Perform the following adjustments before operation:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Open throttling valves to proper setting.
 - 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 - 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 - 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.

7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.12 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Piping Inspections:

- a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
- b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after installation and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
- c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
- d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

- a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
- b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
- c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
- d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
- e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
- f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 Related Requirements:

1. Section 22 05 19 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.

1.2 ACTION SUBMITTALS

- A. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.
- B. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.
- C. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.
- D. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.
- E. Response to Specifications:
 1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
 2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.
 3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
 4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.
- F. Resubmittals Requirements:
 1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
 2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
 3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.
 4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.

- G. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.
- H. Documents submitted shall show the following:
 - 1. Detailed dimensions and details of construction.
 - 2. Operating and maintenance clearances.
 - 3. Installation, operation and maintenance manuals.
- I. Product Data: For each type of product.
- J. Shop Drawings: For domestic water piping specialties.
 - 1. Include diagrams for power, signal, and control wiring.
 - 2. Certifications for lead-free products.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 and NSF 14.
- B. All components associated with water distribution systems shall be lead free in accordance with the 2014 Safe Drinking Water Act (Sec. 1417), latest amendments and with applicable state regulations.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; a division of Watts Water Technologies, Inc.
 - d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze in mechanical room, chrome plated where in finished spaces.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Arrowhead Brass Products.
 - b. Cash Acme; a division of Reliance Worldwide Corporation.
 - c. Conbraco Industries, Inc.
 - d. Legend Valve.
 - e. MIFAB, Inc.
 - f. Prier Products, Inc.
 - g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - h. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - i. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - j. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1011.
3. Body: Bronze, non-removable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Chrome or nickel plated.

C. Spill-Resistant Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Standard: ASSE 1056.
3. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cash Acme; a division of Reliance Worldwide Corporation.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; a division of Watts Water Technologies, Inc.
 - d. Honeywell International Inc.
 - e. Legend Valve.
 - f. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - g. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 2. Standard: ASSE 1012.
 3. Operation: Continuous-pressure applications.
 4. Body: Bronze.
 5. End Connections: Union joint.
 6. Finish: Rough bronze.
- B. Reduced-Pressure-Principle Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; a division of Watts Water Technologies, Inc.
 - d. Flomatic Corporation.
 - e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 2. Standard: ASSE 1013.
 3. Operation: Continuous-pressure applications.
 4. Pressure Loss: 10 psig maximum, through middle third of flow range.
 5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 and larger.
 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 7. Configuration: Designed for horizontal, straight-through flow.
 8. Accessories:
 - a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
- C. Beverage-Dispensing-Equipment Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - c. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.

2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded.

D. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cash Acme; a division of Reliance Worldwide Corporation.
 - b. Lancer Corporation.
 - c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Standard: ASSE 1032.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded.

E. Backflow-Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; a division of Watts Water Technologies, Inc.
 - c. Flomatic Corporation.
 - d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 WATER PRESSURE-REDUCING VALVES

A. Appliance Water Regulators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; a division of Watts Water Technologies, Inc.
 - c. Flomatic Corporation.
 - d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.

4. Design Outlet Pressure Setting: 80 psig maximum.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
6. Valves for Booster Heater Water Supply: Include integral bypass.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water Pressure Reducing Station Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CLA-VAL Corporation.
 - b. Watts; a division of Watts Water Technologies, Inc.
 - c. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.

2.6 BALANCING VALVES

A. Memory-Stop Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Conbraco Industries, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Div.
 - e. Hammond Valve.
 - f. Milwaukee Valve Company.
 - g. NIBCO Inc.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Manifold, Thermostatic, Water Mixing-Valve Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Leonard Valve Company.
 - b. Powers; a division of Watts Water Technologies, Inc.

- c. Symmons Industries, Inc.
 - 2. Description: Factory-fabricated, exposed-mounted, thermostatically controlled, water mixing-valve assembly in two-valve parallel arrangement.
 - 3. Large-Flow Parallel: Thermostatic, water mixing valve and downstream-pressure regulator with pressure gages on inlet and outlet.
 - 4. Intermediate-Flow Parallel: Thermostatic, water mixing valve and downstream-pressure regulator with pressure gages on inlet and outlet.
 - 5. Small-Flow Parallel: Thermostatic, water mixing valve.
 - 6. Thermostatic Mixing Valves: Comply with ASSE 1017. Include check stops on hot- and cold-water inlets and shutoff valve on outlet.
 - 7. Water Regulator(s): Comply with ASSE 1003. Include pressure gage on inlet and outlet.
 - 8. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 9. Thermostatic Mixing Valve and Water Regulator Finish: Rough bronze.
 - 10. Piping Finish: Copper.
- B. Individual-Fixture, Water Tempering Valves:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cash Acme; a division of Reliance Worldwide Corporation.
 - b. Conbraco Industries, Inc.
 - c. Honeywell International Inc.
 - d. Lawler Manufacturing Company, Inc.
 - e. Leonard Valve Company.
 - f. Powers; a division of Watts Water Technologies, Inc.
 - g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - h. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 - 2. Standard: ASSE 1070, thermostatically controlled, water tempering valve.
 - 3. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 4. Body: Bronze body with corrosion-resistant interior components.
 - 5. Temperature Control: Adjustable.
 - 6. Inlets and Outlet: Threaded.
 - 7. Finish: Rough or chrome-plated bronze.
 - 8. Tempered-Water Setting: 105 deg F.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

- A. Y-Pattern Strainers:
 - 1. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
 - 3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 - 4. Screen: Stainless steel with round perforations unless otherwise indicated.
 - 5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
 - c. Strainers NPS 5 and Larger: 0.10 inch.

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

2.9 OUTLET BOXES

A. Clothes Washer Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Acorn Engineering Company.
 - b. Guy Gray Manufacturing Co., Inc.
 - c. IPS Corporation.
 - d. LSP Products Group, Inc.
 - e. Oatey.
 - f. Plastic Oddities.
 - g. Symmons Industries, Inc.
 - h. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - i. Whitehall Manufacturing; a div. of Acorn Engineering Company.
 - j. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
2. Mounting: Recessed.
3. Material and Finish: Stainless-steel box and faceplate.
4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Supply Shutoff Fittings: NPS 1/2 ball valves and NPS 1/2 copper, water tubing.
6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.
7. Inlet Hoses: Two 60-inch- long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
8. Drain Hose: One 48-inch- long, rubber household clothes washer drain hose with hooked end.

B. Refrigerator Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Acorn Engineering Company.
 - b. IPS Corporation.
 - c. LSP Products Group, Inc.
 - d. Oatey.
 - e. Plastic Oddities.
2. Mounting: Recessed.
3. Material and Finish: Stainless-steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.10 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral or field-installation, non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Operating key.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.

2.11 WALL HYDRANTS

A. Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - d. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - e. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASME A112.21.3M for concealed-outlet, freeze-proof self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet:
 - a. Concealed, with integral vacuum breaker or non-removable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
 - b. Garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Nickel bronze.
9. Outlet:
 - a. Concealed, with integral vacuum breaker or non-removable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.

- b. Garden-hose thread complying with ASME B1.20.7.
- 10. Nozzle and Wall-Plate Finish: Nickel bronze.
- 11. Operating Keys(s): One with each wall hydrant.
- B. Vacuum Breaker Wall Hydrants Insert drawing designation if any:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Arrowhead Brass Products.
 - b. Mansfield Plumbing Products LLC.
 - c. McDonald, A. Y. Mfg. Co.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - f. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - g. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - 2. Standard: ASSE 1019, Type A or Type B.
 - 3. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
 - 4. Classification: Type A, for automatic draining with hose removed.
 - 5. Pressure Rating: 125 psig.
 - 6. Operation: Loose key.
 - 7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
 - 8. Inlet: NPS 3/4.
 - 9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.12 GROUND HYDRANTS

- A. Non-freeze Ground Hydrants:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - d. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - e. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
 - 2. Standard: ASME A112.21.3M.
 - 3. Type: Non-freeze, concealed-outlet ground hydrant with box.
 - 4. Operation: Loose key.
 - 5. Casing and Operating Rod: Of at least length required for burial of valve below frost line.
 - 6. Inlet: NPS 3/4.
 - 7. Outlet: Garden-hose thread complying with ASME B1.20.7.
 - 8. Drain: Designed with hole to drain into ground when shut off.
 - 9. Box: Standard pattern with cover.
 - 10. Box and Cover Finish: Polished nickel bronze.
 - 11. Operating Key(s): One with each ground hydrant.

12. Vacuum Breaker: ASSE 1011.

2.13 ROOF HYDRANTS

A. Non-freeze Roof Hydrants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - d. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - e. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASSE 1057.
3. Type: Non-freeze, drainless post hydrant.
4. Operation: Valve handle.
5. Inlet: NPS 3/4.
6. Outlet: Garden-hose thread complying with ASME B1.20.7.
7. Drain: None.
8. Boot Cover: EPDM.
9. Box and Cover Finish: Polished nickel bronze.
10. Support: Cast iron with shims.
11. Vacuum Breaker: ASSE 1052 dual-check with drain.

2.14 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.15 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.

- b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products.
 - g. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
- 2. Standard: ASSE 1010 or PDI-WH 201.
 - 3. Type: Copper tube with piston.
 - 4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.16 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

- 1. Body: Bronze.
- 2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 deg F.
- 3. Float: Replaceable, corrosion-resistant metal.
- 4. Mechanism and Seat: Stainless steel.
- 5. Size: NPS 3/8 minimum inlet.
- 6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

- 1. Body: Stainless steel.
- 2. Pressure Rating: 150-psig minimum pressure rating.
- 3. Float: Replaceable, corrosion-resistant metal.
- 4. Mechanism and Seat: Stainless steel.
- 5. Size: NPS 3/8 minimum inlet.
- 6. Inlet and Vent Outlet End Connections: Threaded.

2.17 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. MIFAB, Inc.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
- 2. Standard: ASSE 1018.
- 3. Pressure Rating: 125 psig minimum.
- 4. Body: Bronze.
- 5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
- 6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
- 7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.18 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Precision Plumbing Products, Inc.
2. Standard: ASSE 1044.
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
4. Cabinet: Surface-mounted steel box with stainless-steel cover.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
 - 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.
6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: Determined from plans.
8. Size Outlets: NPS 1/2.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 1. Locate backflow preventers in same room as connected equipment or system.
 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 3. Do not install bypass piping around backflow preventers.
- B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- C. Install water-control valves with inlet and outlet shutoff valves and bypass. Install pressure gages on inlet and outlet.
- D. Install balancing valves in locations where they can easily be adjusted.
- E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
- F. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve and pump.

- G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Division 06.
- H. Install hose stations with check stops or shutoff valves on inlets.
 - 1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Division 06.
- I. Install ground hydrants with crushed gravel around drain hole. Set ground hydrants with box flush with grade.
- J. Install water-hammer arresters in water piping according to PDI-WH 201.
- K. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.
- L. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
- M. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

- A. Comply with requirements for ground equipment in Section 26 05 26 "Grounding."

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Reduced-pressure-principle backflow preventers.
 - 2. Water pressure-reducing valves.
 - 3. Manifold, thermostatic, water mixing-valve assemblies.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test each reduced-pressure-principle backflow preventer double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221123.21 - INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line, sealless centrifugal pumps.
2. Horizontally mounted, in-line, separately coupled centrifugal pumps.
3. Horizontally mounted, in-line, close-coupled centrifugal pumps.
4. Vertically mounted, in-line, close-coupled centrifugal pumps.

B. Related Requirements:

1. Section 221123.13 "Domestic-Water Packaged Booster Pumps" for booster systems.
2. Section 331113 "Potable Water Supply Wells" for well pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. [<Double click to insert sustainable design text for pump controls.>](#)

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail pumps and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, 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. Structural members to which pumps will be attached.
2. Size and location of initial access modules for acoustical tile.

B. Seismic Qualification Data: Certificates, for inline, domestic-water pumps, 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.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For inline, domestic-water pumps to include in operation and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written instructions for handling.

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. UL Compliance: UL 778 for motor-operated water pumps.
- C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- D. <Insert local jurisdiction requirement>.
- E. Seismic Performance: Inline, domestic-water pumps 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].
 - 3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

2.2 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
- B. Capacities and Characteristics:
 - 1. Capacity: <Insert **gpm** >.
 - 2. Total Dynamic Head: <Insert **feet** >.
 - 3. Inlet and Outlet Size: <Insert **NPS** >.

4. Pump Speed: <Insert rpm>.
5. Pump Control: [Pressure switch] [Thermostat] [Timer].
6. Motor Horsepower: <Insert value> HP.
7. Electrical Characteristics:
 - a. Volts: [120] <Insert number> V.
 - b. Phase: [Single] <Insert number> phase.
 - c. Hertz: [60] <Insert number> Hz.
 - d. Full-Load Amperes: <Insert value> A.
 - e. Minimum Circuit Ampacity: <Insert number> A.
 - f. Maximum Overcurrent Protection: <Insert number> A.

C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Minimum Working Pressure: [125 psig] <Insert pressure>.
3. Maximum Continuous Operating Temperature: [220 deg F] <Insert temperature>.
4. Casing: [Cast iron] [Bronze] [Stainless steel], with threaded or companion-flange connections.
5. Impeller: [Plastic] [composite] [or] [stainless steel].
6. Motor: [Single] [Three] speed.
7. <Insert options>.

2.3 HORIZONTALLY MOUNTED, IN-LINE, SEPARATELY COUPLED CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, single-stage, separately coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shafts mounted horizontal.

B. Capacities and Characteristics:

1. Capacity: <Insert gpm >.
2. Total Dynamic Head: <Insert feet >.
3. Inlet and Outlet Size: <Insert NPS >.
4. Pump Speed: <Insert rpm>.
5. Pump Control: [Pressure switch] [Thermostat] [Timer].
6. Motor Horsepower: <Insert value>.
7. Electrical Characteristics:
 - a. Volts: [120] [240] <Insert number> V.
 - b. Phases: [Single] [Three] phase.
 - c. Hertz: [60] <Insert number> Hz.
 - d. Full-Load Amperes: <Insert number> A.
 - e. Minimum Circuit Ampacity: <Insert number> A.
 - f. Maximum Overcurrent Protection: <Insert number> A.

C. Pump Construction:

1. Casing:

- a. Radially split [bronze] [cast iron] [or] [stainless steel] with threaded companion-flange connections for pumps with **NPS 2** pipe connections and flanged connections for pumps with **NPS 2-1/2** pipe connections.
 - b. Built to permit servicing of pump internals without disturbing the casing or the suction and discharge piping.
 - c. Gauge port tapings at suction and discharge nozzles.
2. Impeller: [Bronze] [or] [stainless steel], statically and dynamically balanced, closed, and keyed to shaft.
 3. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 4. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
 5. Seal: Mechanical, with [carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket] <Insert seal type>.
 6. Bearings: [Grease-lubricated] [or] [permanently lubricated] ball type.
 7. Minimum Working Pressure: [**125 psig**] [**175 psig**] <Insert pressure>.
 8. Continuous Operating Temperature: [**200 deg F**] <Insert temperature>.
- D. Motor: Single speed, with permanently lubricated ball bearings; and [resiliently] [or] [rigidly] mounted to pump casing.

2.4 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.
- B. Capacities and Characteristics:
1. Capacity: <Insert **gpm**>.
 2. Total Dynamic Head: <Insert **feet**>.
 3. Inlet and Outlet Size: <Insert **NPS**>.
 4. Pump Control: [Pressure switch] [Thermostat] [Timer].
 5. Pump Speed: <Insert rpm>.
 6. Motor Horsepower: <Insert value>.
 7. Electrical Characteristics:
 - a. Volts: [120] [240] <Insert number> V.
 - b. Phases: [Single] [Three] phase.
 - c. Hertz: [60] <Insert number> Hz.
 - d. Full-Load Amperes: <Insert number> A.
 - e. Minimum Circuit Ampacity: <Insert number> A.
 - f. Maximum Overcurrent Protection: <Insert number> A.
- C. Pump Construction:
1. Casing:
 - a. Radially split [bronze] [brass] [or] [cast iron] with threaded companion-flange connections for pumps with **NPS 2** pipe connections and flanged connections for pumps with **NPS 2-1/2** pipe connections.
 - b. Built to permit servicing of pump internals without disturbing the casing or the suction and discharge piping.
 - c. Gauge port tapings at suction and discharge nozzles.

2. Impeller: [Bronze] [or] [brass], statically and dynamically balanced, closed, and keyed to shaft.
 3. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
 4. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
 5. Seal: Mechanical, with [carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket] <Insert seal type>.
 6. Bearings: [Grease-lubricated] [or] [permanently lubricated] ball type.
 7. Minimum Working Pressure: [175 psig] <Insert pressure>.
 8. Continuous Operating Temperature: [225 deg F] <Insert temperature>.
- D. Motor: Single speed, with grease-lubricated ball bearings; [resiliently] [or] [rigidly] mounted to pump casing.

2.5 VERTICALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.
- B. Capacities and Characteristics:
1. Capacity: <Insert gpm >.
 2. Total Dynamic Head: <Insert feet >.
 3. Casing Material: [Bronze] [Cast iron].
 4. Impeller Material: [ASTM B584, cast bronze] [ASTM B584, cast bronze or stainless steel] [Stainless steel].
 5. Minimum Operating Pressure: 175 psig .
 6. Maximum Continuous Operating Temperature: 225 deg F .
 7. Inlet and Outlet Size: <Insert NPS >.
 8. Pump Control: [Pressure switch] [Thermostat] [Timer].
 9. Pump Speed: <Insert rpm>.
 10. Motor Horsepower: <Insert value>.
 11. Electrical Characteristics:
 - a. Volts: [120] [240] <Insert number> V.
 - b. Phases: [Single] [Three] phase.
 - c. Hertz: [60] <Insert number> Hz.
 - d. Full-Load Amperes: <Insert number> A.
 - e. Minimum Circuit Ampacity: <Insert number> A.
 - f. Maximum Overcurrent Protection: <Insert number> A.
- C. Pump Construction:
1. Casing: Radially split [bronze] [cast or ductile iron], with wear rings and threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.[Include pump manufacturer's base attachment for mounting pump on concrete base.]
 2. Impeller: [Bronze] [brass] [or] [stainless steel], statically and dynamically balanced, closed, and keyed to shaft.
 3. Shaft and Shaft Sleeve: [Steel] [or] [stainless-steel] shaft, with copper-alloy shaft sleeve.
 4. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.
 5. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.

6. Bearings: Oil-lubricated; bronze-journal or ball type.
7. Minimum Working Pressure: [175 psig] <Insert pressure>.
8. Continuous Operating Temperature: [225 deg F] <Insert temperature>.

D. Motor: Single speed, with grease-lubricated ball bearings; rigidly mounted to pump casing.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220500 "Common Work Results for Plumbing."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.7 CONTROLS

- A. Pressure Switches: Electric, adjustable for control of [water-supply] <Insert application> pump.
1. Type: Water-immersion pressure sensor, for installation in piping.
 2. Enclosure: NEMA 250, [Type 4X] <Insert type>.
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.
 5. Power Requirement: [24 V ac] [120 V ac] <Insert power>.
 6. Settings: Start pump at <Insert pressure> and stop pump at <Insert pressure>.
- B. Thermostats: Electric; adjustable for control of [hot-water circulation] <Insert application> pump.
1. Type: Water-immersion temperature sensor, for installation in piping.
 2. Range: [50 to 125 deg F] [65 to 200 deg F] [100 to 240 deg F] <Insert temperature range>.
 3. Enclosure: NEMA 250, [Type 4X] <Insert type>.
 4. Operation of Pump: On or off.
 5. Transformer: Provide if required.
 6. Power Requirement: [24 V ac] [120 V ac] <Insert power>.
 7. Settings: Start pump at [105 deg F] [110 deg F] [115 deg F] <Insert temperature> and stop pump at [120 deg F] [125 deg F] <Insert temperature>.
- C. Timers: Electric, for control of [hot-water circulation] <Insert application> pump.
1. Type: Programmable, [seven-day] <Insert time> clock with manual override on-off switch.
 2. Enclosure: NEMA 250, [Type 1] <Insert type>, suitable for wall mounting.
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.
 5. Power Requirement: [24 V ac] [120 V ac] <Insert power>.
 6. Programmable Sequence of Operation: [Up to two on-off cycles each day for seven days] <Insert operational sequence>.
- D. Time-Delay Relays: Electric, for control of hot-water circulation pump between water heater and connected hot-water storage tank.
1. Type: Adjustable time-delay relay.

2. Range: Up to five minutes.
3. Setting: Five minutes.
4. Enclosure: NEMA 250, [Type 4X] <Insert type>.
5. Operation of Pump: On or off.
6. Transformer: Provide if required.
7. Power Requirement: [24 V ac] [120 V ac] <Insert power>.
8. Programmable Sequence of Operation: Limit pump operation to periods of burner operation, plus maximum five minutes after the burner stops.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.

3.2 INSTALLATION OF PUMPS

- A. Comply with HI 1.4.
- B. Mount pumps in orientation complying with manufacturer's written instructions.
- C. Pump Mounting:
 1. Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using vibration isolation type and deflection as specified in [Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."] [Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."] Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 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.
- D. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.
 1. Comply with requirements for vibration isolation devices specified in [Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."] [Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."] Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- E. Install pressure switches in water-supply piping.
- F. Install thermostats in hot-water return piping.

- G. Install timers [on wall in engineer's office] <Insert location>.
- H. Install time-delay relays in piping between water heaters and hot-water storage tanks.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.
- C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - d. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 1. Install pressure gauge[and snubber] at suction of each pump and pressure gauge[and snubber] at discharge of each pump. Install at integral pressure-gauge tapings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 220500 "Common Work Results for Plumbing."

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between temperature controllers and devices.
- C. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. 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 tests and inspections[with the assistance of a factory-authorized service representative].
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. [Engage a factory-authorized service representative to perform] [Perform] startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set [pressure switches,] [thermostats,] [timers,] [and] [time-delay relays] for automatic starting and stopping operation of pumps.
 - 5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 7. Start motor.
 - 8. Open discharge valve slowly.
 - 9. Adjust temperature settings on thermostats.
 - 10. Adjust timer settings.

3.8 ADJUSTING

- A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123.21

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Galvanized-steel pipe and fittings.
4. Copper tube and fittings.
5. PVC pipe and fittings.

B. Related Requirements:

1. Section 221329 "Sanitary Sewerage Pumps" for effluent and sewage pumps.
2. Section 226600 "Chemical-Waste Systems for Laboratory and Healthcare Facilities" for chemical-waste and vent piping systems.
3. Section 333115 "Site Sanitary Sewerage Piping" for sanitary sewerage piping and structures outside the building.

1.2 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Waste, Force-Main Piping: 150 psig.

1.3 ACTION SUBMITTALS

- A. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.
- B. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.
- C. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.
- D. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.
- E. Response to Specifications:

1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.
3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.

F. Resubmittals Requirements:

1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.
4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.

G. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.

H. Documents submitted shall show the following:

1. Detailed dimensions and details of construction.

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.**

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.**

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service class(es).
- B. Gaskets: ASTM C 564, rubber.
- C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. CISPI, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ANACO-Husky.
 - b. Dallas Specialty & Mfg. Co.
 - c. Fernco Inc.
 - d. Matco-Norca, Inc.
 - e. MIFAB, Inc.
 - f. Mission Rubber Company; a division of MCP Industries, Inc.
 - g. Stant.
 - h. Tyler Pipe.
 - 2. Standards: ASTM C 1277 and CISPI 310.
 - 3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- C. Heavy-Duty, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ANACO-Husky.
 - b. Clamp-All Corp.
 - c. MIFAB, Inc.
 - d. Tyler Pipe.
 - 2. Standards: ASTM C 1277 and ASTM C 1540.
 - 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

- C. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
- D. Copper Pressure Fittings:
 - 1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- E. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 - 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- F. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 - 1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
 - 2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 - 3. Shielded, Non-pressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company; a division of MCP Industries, Inc.
 - b. Standard: ASTM C 1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 4. Pressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Dresser, Inc.
 - 3) EBAA Iron, Inc.
 - 4) JCM Industries, Inc.
 - 5) Romac Industries, Inc.
 - 6) Smith-Blair, Inc.; a Sensus company.
 - 7) The Ford Meter Box Company, Inc.

8) Viking Johnson.

- b. Standard: AWWA C219.
- c. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
- d. Center-Sleeve Material: Stainless steel Ductile iron.
- e. Gasket Material: Natural or synthetic rubber.
- f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

- 1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- 2. Dielectric Unions:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 1) Capitol Manufacturing Company.
- 2) Central Plastics Company.
- 3) Hart Industries International, Inc.
- 4) Jomar International Ltd.
- 5) Matco-Norca, Inc.
- 6) McDonald, A.Y. Mfg. Co.
- 7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 8) Wilkins; a Zurn company.

b. Description:

- 1) Standard: ASSE 1079.
- 2) Pressure Rating: 125 psig minimum at 180 deg F.
- 3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 1) Capitol Manufacturing Company.
- 2) Central Plastics Company.
- 3) Matco-Norca, Inc.
- 4) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 5) Wilkins; a Zurn company.

b. Description:

- 1) Standard: ASSE 1079.
- 2) Factory-fabricated, bolted, companion-flange assembly.
- 3) Pressure Rating: 125 psig minimum at 180 deg F.
- 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Advance Products & Systems, Inc.
 - 2) Calpico, Inc.
 - 3) Central Plastics Company.
 - 4) Pipeline Seal and Insulator, Inc.
 - b. Description:
 - 1) Non-conducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig.
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel backing washers.
5. Dielectric Nipples:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Elster Perfection.
 - 2) Grinnell Mechanical Products.
 - 3) Matco-Norca, Inc.
 - 4) Precision Plumbing Products, Inc.
 - 5) Victaulic Company.
 - b. Description:
 - 1) Standard: IAPMO PS 66
 - 2) Electroplated steel nipple.
 - 3) Pressure Rating: 300 psig at 225 deg F.
 - 4) End Connections: Male threaded or grooved.
 - 5) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction

loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at code required slopes unless otherwise noted on the drawings.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow for piping NPS 3 and smaller, 1 percent downward in the direction of flow for piping NPS 4 and larger.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

- O. Install aboveground ABS piping according to ASTM D 2661.
- P. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
 - 1. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
- Q. Install force mains at elevations indicated.
- R. Plumbing Specialties:
 - 1. Install backwater valves in sanitary waste gravity-flow piping where indicated on drawings. Comply with requirements for backwater valves specified in Section 221319.01 "Sanitary Waste Piping Specialties."
 - 2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 221319.01 "Sanitary Waste Piping Specialties."
 - 3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 221319.01 "Sanitary Waste Piping Specialties."
- S. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- T. Install sleeves for piping penetrations of walls, ceilings, and floors above slab on grade. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install sleeve seals for piping penetrations of concrete walls. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and raised floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.
- C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- E. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- F. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- G. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in OD's.
 - 2. In Drainage Piping: Shielded, non-pressure transition couplings.
 - 3. In Aboveground Force Main Piping: Fitting-type transition couplings.
 - 4. In Underground Force Main Piping:
 - a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
 - b. NPS 2 and Larger: Pressure transition couplings.
- B. Dielectric Fittings:
 - 1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - 2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
 - 3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.
 - 4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

- A. General valve installation requirements are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- B. Shutoff Valves:
 - 1. Install shutoff valve on each sewage pump discharge.
 - 2. Install butterfly full-port ball valve for piping NPS 2 and smaller.
 - 3. Install butterfly valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
 - 2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
 - 3. Install backwater valves in accessible locations.
 - 4. Comply with requirements for backwater valve specified in Section 221319.01 "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 - 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 6. Install individual, straight, horizontal piping runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - 7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 8. Base of Vertical Piping: MSS Type 52.
- B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 - 5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
 - 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 - 3. NPS 2: 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 - 5. NPS 3: 12 feet with 1/2-inch rod.
 - 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 - 7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
 - 8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.
- H. Install supports for vertical steel piping every 15 feet.
- I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: 84 inches with 3/8-inch rod.
 2. NPS 3: 96 inches with 1/2-inch rod.
 3. NPS 4: 108 inches with 1/2-inch rod.
 4. NPS 6: 10 feet with 5/8-inch rod.
- J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
 5. NPS 6: 10 feet with 5/8-inch rod.
 6. NPS 8: 10 feet with 3/4-inch rod.
- K. Install supports for vertical copper tubing every 10 feet.
- L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 5. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.
 6. Comply with requirements for backwater valves, cleanouts and drains specified in Section 221319.01 "Sanitary Waste Piping Specialties."
 7. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- D. Connect force-main piping to the following:
1. Sanitary Sewer: To exterior force main.
 2. Sewage Pump: To sewage pump discharge.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

- F. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 - 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 6. Prepare reports for tests and required corrective action.

- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
 - 3. Copper DWV tube, copper drainage fittings, and soldered joints.
- C. Aboveground, soil and waste piping NPS 5 and larger shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
- D. Aboveground, vent piping NPS 10 and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
 - 3. Copper DWV tube, copper drainage fittings, and soldered joints.
 - a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 4. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.

- E. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
 - 1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 2. Galvanized-steel pipe, pressure fittings, and threaded joints.

- F. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 shall be any of the following:
 - 1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 2. Galvanized-steel pipe, pressure fittings, and threaded joints.
 - 3. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.

END OF SECTION 221316

SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Floor drains.
 - 2. Floor sinks.
 - 3. Trench drains.
 - 4. Concrete trench drain-forming system.

1.2 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene styrene.
- B. FRP: Fiberglass-reinforced plastic.
- C. HDPE: High-density polyethylene.
- D. PE: Polyethylene.
- E. PP: Polypropylene.
- F. PVC: Polyvinyl chloride.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sanitary drains are to bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

- A. Floor Drain - Cast Iron <Insert drawing designation>:
 - 1. Source Limitations: Obtain cast-iron floor drains from single manufacturer.
 - 2. Standard: ASME A112.6.3[with backwater valve].

3. Pattern: [Area] [Floor] [Funnel floor] [Sanitary] <Insert pattern> drain.
4. Body Material: [Gray iron] <Insert material>.
5. Seepage Flange: [Not required] [Required].
6. Anchor Flange: [Not required] [Required].
7. Clamping Device: [Not required] [Required].
8. Outlet: [Bottom] [Side] <Insert type>.
9. Backwater Valve: [Drain-outlet type] [Integral, ASME A112.14.1, swing-check type] [Not required].
10. Coating on Interior and Exposed Exterior Surfaces: [Acid-resistant enamel] [Not required] <Insert material>.
11. Sediment Bucket: [Not required] <Insert description>.
12. Top or Strainer Material: [Bronze] [Gray iron] [Nickel bronze] [Stainless steel] <Insert material>.
13. Top of Body and Strainer Finish: [Nickel bronze] [Polished bronze] [Rough bronze] [Stainless steel] <Insert finish>.
14. Top Shape: [Round] [Square] <Insert shape>.
15. Dimensions of Top or Strainer: <Insert dimensions and describe body, sump, and grate>.
16. Top Loading Classification: [Extra Heavy Duty] [Heavy Duty] [Light Duty] [Medium Duty].
17. Funnel: [Not required] [Required] <Insert description and dimensions>.
18. Inlet Fitting: [Not required] [Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection].
19. Trap Material: [Bronze] [Cast iron] [Copper] [Not required] <Insert material>.
20. Trap Pattern: [Deep-seal P-trap] [Standard P-trap] [Not required] <Insert pattern>.
21. Trap Features: [Cleanout] [Trap-seal primer valve drain connection] [Cleanout and trap-seal primer valve drain connection] [Not required] <Insert type>.

B. Floor Drain - Stainless Steel, ASME A112.3.1 <Insert drawing designation>:

1. Source Limitations: Obtain stainless steel floor drains, ASME A112.3.1, from single manufacturer.
2. Standard: ASME A112.3.1.
3. Outlet: [Bottom] [Side] <Insert type>.
4. Top or Strainer Material: [Stainless steel] <Insert material>.
5. Top Shape: [Round] [Square] <Insert shape>.
6. Dimensions of Top or Strainer: <Insert dimensions and describe body, sump, and grate>.
7. Seepage Flange: [Not required] [Required].
8. Anchor Flange: [Not required] [Required].
9. Clamping Device: [Not required] [Required].
10. Trap-Primer Connection: [Not required] [Required].
11. Trap Material: [Cast iron] [Stainless steel] [Not required] <Insert material>.
12. Trap Pattern: [Deep-seal P-trap] [Standard P-trap] [Not required] <Insert pattern>.

C. Floor Drain - Stainless Steel, ASME A112.6.3 <Insert drawing designation>:

1. Source Limitations: Obtain stainless steel floor drains, ASME A112.6.3, from single manufacturer.
2. Standard: ASTM A112.6.3.
3. Outlet: [Bottom] [Side] <Insert type>.
4. Top or Strainer Material: [Stainless steel] <Insert material>.
5. Top Shape: [Round] [Square] <Insert shape>.
6. Dimensions of Top or Strainer: <Insert dimensions and describe body, sump, and grate>.
7. Seepage Flange: [Not required] [Required].
8. Anchor Flange: [Not required] [Required].
9. Clamping Device: [Not required] [Required].

10. Trap-Primer Connection: [Not required] [Required].
11. Trap Material: [Cast iron] [Stainless steel] [Not required] <Insert material>.
12. Trap Pattern: [Deep-seal P-trap] [Standard P-trap] [Not required] <Insert pattern>.

D. Floor Drain - Plastic <Insert drawing designation>:

1. Source Limitations: Obtain plastic floor drains from single manufacturer.
2. Standard: ASME A112.6.3.
3. Material: [ABS] [or] [PVC] <Insert material>.
4. Seepage Flange: [Not required] [Required].
5. Clamping Device: [Not required] [Required].
6. Outlet: [Bottom] [Side] <Insert type>.
7. Sediment Bucket: [Not required] <Insert description>.
8. Top or Strainer Material: [Bronze] [Plastic] [Stainless steel] <Insert other>.
9. Top of Body and Strainer Finish: [Nickel bronze] [Polished bronze] [Rough bronze] [Stainless steel] <Insert other>.
10. Top Shape: [Round] [Square] <Insert shape>.
11. Dimensions of Top or Strainer: <Insert dimensions and describe body, sump, and grate if required>.
12. Trap Material: [Cast iron] [Plastic drainage piping] [Not required] <Insert material>.
13. Trap Pattern: [Standard P-trap] [Not required] <Insert pattern>.

2.3 FLOOR SINKS

A. Floor Sink - Cast Iron <Insert drawing designation>:

1. Source Limitations: Obtain cast-iron floor sinks from single manufacturer.
2. Standard: ASME A112.6.7.
3. Pattern: [Floor] [Funnel floor] <Insert pattern> drain.
4. Body Material: Cast iron.
5. Anchor Flange: [Not required] [Required][, with seepage holes].
6. Clamping Device: [Not required] [Required].
7. Outlet: Bottom, [no-hub] <Insert type> connection.
8. Coating on Interior Surfaces: [Not required] [Acid-resistant enamel] <Insert coating>.
9. Sediment Bucket: [Not required] <Insert description>.
10. Internal Strainer: [Not required] [Dome] [Flat].
11. Internal Strainer Material: [Aluminum] <Insert material>.
12. Top Grate Material: [Cast iron] <Insert material> [, loose][, hinged].
13. Top of Body and Grate Finish: [Nickel bronze] [Acid-resistant enamel] <Insert finish>.
14. Top Shape: [Round] [Square] <Insert shape>.
15. Dimensions of Top Grate: <Insert dimensions and describe grate pattern>.
16. Top Loading Classification: [No traffic] <Insert traffic loading>.
17. Funnel: [Not required] [Required]. <Insert material, shape and dimensions>.
18. <Insert additional options here>.

B. Floor Sink - Stainless Steel <Insert drawing designation>:

1. Source Limitations: Obtain stainless steel floor sinks from single manufacturer.
2. Standard: ASME A112.6.7.
3. Pattern: [Floor] [Funnel floor] <Insert pattern> drain.
4. Body Material: Stainless steel.
5. Anchor Flange: [Not required] [Required][, with seepage holes].
6. Clamping Device: [Not required] [Required].

7. Outlet: Bottom, [no-hub] <Insert type> connection.
8. Sediment Bucket: [Not required] <Insert description>.
9. Internal Strainer: [Not required] [Dome] [Flat].
10. Internal Strainer Material: [Stainless steel] <Insert material>.
11. Top Grate Material: [Stainless steel] <Insert material> [, loose] [, hinged].
12. Top of Body and Grate Finish: [Satin nickel] [Stainless steel] <Insert finish>.
13. Top Shape: [Round] [Square] <Insert shape>.
14. Dimensions of Top Grate: <Insert dimensions and describe grate pattern>.
15. Top Loading Classification: [No traffic] <Insert traffic loading>.
16. Funnel: [Not required] [Required]. <Insert material, shape and dimensions>.
17. <Insert additional options here>.

C. Floor Sink - Plastic <Insert drawing designation>:

1. Source Limitations: Obtain plastic floor sinks from single manufacturer.
2. Standard: ASME A112.6.7.
3. Pattern: [Floor] [Funnel floor] <Insert pattern> drain.
4. Body Material: PVC.
5. Outlet: Bottom, PVC primer and solvent cement connection.
6. Sediment Bucket: [Not required] <Insert description>.
7. Internal Strainer: [Not required] [Dome] [Flat].
8. Internal Strainer Material: [PVC] <Insert material>.
9. Top Grate Material: [PVC] <Insert material>.
10. Top Shape: [Round] [Square] <Insert shape>.
11. Dimensions of Top Grate: <Insert dimensions and describe grate pattern>.
12. Top Loading Classification: [No traffic] <Insert traffic loading>.
13. Funnel: [Not required] [Required]. <Insert material, shape and dimensions>.
14. <Insert additional options here>.

2.4 TRENCH DRAINS

A. Trench Drain, Individual - Cast Iron or Ductile Iron <Insert drawing designation>:

1. Source Limitations: Obtain trench drains from single manufacturer.
2. Standard: ASME A112.6.3 for trench drains.
3. Material: Cast iron or ductile iron body.
4. Flange: [Anchor] [Seepage] [Not required].
5. Clamping Device: [Not required] [Required].
6. Outlet: [Bottom] [End] [Side] <Insert location>.
7. Grate Material: [Ductile iron] [Ductile iron or gray iron] [Gray iron] [Stainless steel] <Insert material>.
8. Grate Finish: [Painted] [Not required] <Insert finish>.
9. Dimensions of Frame and Grate: <Insert dimensions and describe body, sump, and grate if required>.
10. Top Loading Classification: [Extra Heavy Duty] [Heavy Duty] [Light Duty] [Medium Duty].
11. Trap Material: [Cast iron] [Stainless steel] [Not required] <Insert material>.
12. Trap Pattern: [Standard P-trap] [Not required] <Insert pattern>.

B. Trench Drain, Individual - Stainless Steel <Insert drawing designation>:

1. Source Limitations: Obtain stainless steel trench drain from single manufacturer.

2. Description: Stainless steel trench consisting of sloped trench body, grates, and appurtenances; designed so grates fit into trench body recesses without rocking or rattling.
 3. Standard: ASME A112.6.3.
 4. Dimensions: <Insert dimensions> wide by <Insert dimensions long>.
 5. Grates: Manufacturer's designation "[Heavy] [Medium] Duty," with slots or perforations, and of width and thickness that fit recesses in channels.
 - a. Material: Stainless steel.
 - b. Locking Mechanism: [Manufacturer's standard device for securing grates to body channel] [Not required].
 6. Covers: Solid stainless steel of width and thickness that fit recesses in channel, and of length indicated.
 7. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
- C. Trench Drain, Modular Channel System - Stainless Steel <Insert drawing designation>:
1. Source Limitations: Obtain modular stainless steel channel systems, from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of stainless steel channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Interlocking joint, stainless steel with level invert.
 - a. Dimensions: [6 inches (152 mm)] [12 inches (305 mm)] wide. Include number of units required to form total lengths indicated.
 5. Grates: Manufacturer's designation "[Heavy] [Medium] Duty," with slots or perforations, and of width and thickness that fit recesses in channels.
 - a. Material: [Ductile iron] [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].
 6. Covers: Solid [ductile or gray iron] [stainless steel] <Insert material>, of width and thickness that fit recesses in channels, and of lengths indicated.
 7. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 8. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- D. Trench Drain, Modular Channel System - Polymer Concrete, Narrow, Sloped Invert <Insert drawing designation>:
1. Source Limitations: Obtain narrow, sloped-invert, polymer-concrete channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps.

- a. Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated.
 - b. Include extension sections necessary for required depth.
 - c. Dimensions: [4-inch (102-mm)] <Insert dimension> inside width. Include number of units required to form total lengths indicated.
 - d. Frame: [Gray-iron, cast iron, or galvanized steel for grates] [Not required] <Insert material>.
 5. Grates: Manufacturer's designation "[Heavy] [Medium] Duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.
 - a. Material: [Ductile iron] [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].
 6. Covers: Solid [ductile or gray iron] <Insert material>, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 7. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 8. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- E. Trench Drain, Modular Channel System - Polymer Concrete, Narrow, Level Invert <Insert drawing designation>:
1. Source Limitations: Obtain narrow, level-insert, polymer-concrete channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Narrow, interlocking-joint, precast, polymer-concrete modular units with end caps.
 - a. Include rounded bottom, with level invert and with NPS 4 (DN 100) outlets in number and locations indicated.
 - b. Dimensions: [5-inch (127-mm)] <Insert dimension> inside width and [9-3/4 inches (248 mm)] <Insert dimension> inside depth. Include number of units required to form total lengths indicated.
 - c. Frame: [Gray-iron or galvanized steel for grates] [Not required] <Insert material>.
 5. Grates: Manufacturer's designation "[Heavy] [Medium] Duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.
 - a. Material: [Ductile iron] [Fiberglass] [Galvanized steel] [Cast iron or gray iron] [Stainless steel] <Insert material>.
 - b. Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].
 6. Covers: Solid [ductile, cast, or gray iron] <Insert material>, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 7. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.

8. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- F. Trench Drain, Modular Channel System - Polymer Concrete, Wide, Level Invert <Insert drawing designation>:
1. Source Limitations: Obtain wide, level-insert, polymer-concrete channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Wide, interlocking-joint, precast, polymer-concrete modular units with end caps.
 - a. Include flat or rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.
 - b. Dimensions: [8-inch (203-mm)] <Insert dimension> inside width and [13-3/4 inches (350 mm)] <Insert dimension> inside depth. Include number of units required to form total lengths indicated.
 - c. Frame: [Galvanized steel, gray iron, or cast iron for grates] [Not required] <Insert material>.
 5. Grates: Manufacturer's designation "[Heavy] [Medium] Duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.
 - a. Material: [Ductile iron] [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].
 6. Covers: Solid [ductile or gray iron] <Insert material>, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 7. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 8. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- G. Trench Drain, Modular Channel System - FRP <Insert drawing designation>:
1. Source Limitations: Obtain FRP channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Interlocking-joint, sloped-invert, FRP modular units, with end caps. Include flat, rounded, or inclined inside bottom, with outlets in number, sizes, and locations indicated.
 - a. Dimensions: [4 inches (102 mm)] [4 or 6 inches (102 or 152 mm)] [6 inches (152 mm)] [6 or 8 inches (152 or 203 mm)] [8 inches (203 mm)] wide. Include number of units required to form total lengths indicated.
 - b. Frame: [Galvanized steel] [Stainless steel] [Manufacturer's standard metal] <Insert material> for grates.

5. Grates: With slots or perforations and widths and thickness that fit recesses in channel sections.
 - a. Material: [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].
 6. Covers: Solid [ductile or gray iron] <Insert material>, of width and thickness that fit recesses in channel sections, and of lengths indicated.
 7. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 8. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- H. Trench Drain, Modular Channel System - HDPE or PE <Insert drawing designation>:
1. Source Limitations: Obtain HDPE or PE channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Interlocking-joint, HDPE or PE modular units, with end caps. Include flat, rounded, or inclined bottom, with level invert and with outlets in number, sizes, and locations indicated.
 - a. Dimensions: 4 inches (102 mm) wide. Include number of units required to form total lengths indicated.
 5. Grates: With slots or perforations and widths and thickness that fit recesses in channel sections.
 - a. Material: [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Color: <Insert color or delete subparagraph>.
 6. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- I. Trench Drain, Modular Channel System - PP <Insert drawing designation>:
1. Source Limitations: Obtain PP channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Interlocking-joint, PP modular units, with end caps. Include flat, rounded, or inclined bottom, with level invert and with outlets in number, sizes, and locations indicated.
 - a. Dimensions: 4 inches (102 mm) wide. Include number of units required to form total lengths indicated.

5. Grates: With slots or perforations and widths and thickness that fit recesses in channel sections.
 - a. Material: [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Color: <Insert color or delete subparagraph>.
 6. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- J. Trench Drain, Modular Channel System - PVC <Insert drawing designation>:
1. Source Limitations: Obtain PVC channel drainage systems from single manufacturer.
 2. Standard: ASME A112.6.8.
 3. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 4. Channel Sections: Interlocking-joint, PVC modular units, with end caps. Include flat, rounded, or inclined bottom, with level invert and with outlets in number, sizes, and locations indicated.
 - a. Dimensions: 4 inches (102 mm) wide. Include number of units required to form total lengths indicated.
 5. Grates: With slots or perforations and widths and thickness that fit recesses in channel sections.
 - a. Material: [Fiberglass] [Galvanized steel] [Gray iron] [Stainless steel] <Insert material>.
 - b. Color: <Insert color or delete subparagraph>.
 6. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
 7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.5 CONCRETE TRENCH DRAIN-FORMING SYSTEM

- A. Concrete Trench Drain-Forming System: <Insert drawing designation>.
1. Source Limitations: Obtain concrete trench drain-forming system from single manufacturer.
 2. Description: Radius trench-drain-forming system, including a removable form that is customizable for width, depth, length, shape, slope, frame material, and grate material.
 3. Form Bottom: [Smooth radius] [Vee] [Flat] <Insert option>.
 4. Form Use: [Single use] [or] [reusable].
 5. Form Covers: Plywood or metal to keep concrete out of trench form during installation.
 6. Width: [8-inch (203-mm)] [10-inch (254-mm)] [12-inch (305-mm)] [18-inch (457-mm)] [24-inch (610-mm)] <Insert width> inside dimension.
 7. Depth: [See Drawings] <Insert dimension>.
 8. Length: [See Drawings] <Insert dimension>.
 9. Bottom Shape: [Smooth radius] [Vee] <Insert shape>.

10. Slope: [Level - no slope] [0.5 percent] [0.6 percent] [1.0 percent] <Insert slope>.
11. Frame/Grate Seat:
 - a. Load Bearing, <Insert loading requirement>.
 - b. Material: [Powder-coated steel] [Galvanized steel] [Iron] [Aluminum] [Plastic] [FRP] [Stainless steel] <Insert material>.
12. Concrete Anchors: [**18 inches** (**457 mm**) o.c.] <Insert spacing>.
13. Grate:
 - a. Manufacturer's Load Bearing Designation: "[Heavy] [Medium] Duty".
 - b. Material: [Ductile iron] [FRP] [Galvanized steel] [Cast iron] [Stainless steel] <Insert material>.
 - c. Grate Type: [ADA] [Heel-proof] [slotted] [perforated] [bar] <Insert grate type>.

PART 3 - EXECUTION

3.1 INSTALLATION OF SANITARY DRAINS

- A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 3. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than **1/4-inch** (**6.35-mm**) total depression.
 - b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
 - c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than **1-inch** (**25-mm**) total depression.
 4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- B. Install trench drains at low points of surface areas to be drained.
 1. Set grates of drains flush with finished surface, unless otherwise indicated.
- C. Comply with ASME A112.3.1 for installation of stainless steel channel drainage systems.
 1. Install on support devices, so that top will be flush with adjacent surface.
- D. Install FRP channel drainage system components on support devices, so that top will be flush with adjacent surface.

- E. Install plastic channel drainage system components on support devices, so that top will be flush with adjacent surface.
- F. Install open drain fittings with top of hub [1 inch (25 mm)] [2 inches (51 mm)] <Insert dimension> above floor.

3.2 PIPING CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.
- C. Comply with requirements in Section 221323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.
- D. Install piping adjacent to equipment to allow service and maintenance.

3.3 ELECTRICAL 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."

3.4 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 221319.01 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Backwater valves.
 - 2. Cleanouts.
 - 3. Floor drains.
 - 4. Through-penetration firestop assemblies.
 - 5. Miscellaneous sanitary drainage piping specialties.
 - 6. Flashing materials.
- B. Related Requirements:
 - 1. Section 221423 "Storm Drainage Piping Specialties" for storm drainage piping inside the building, drainage piping specialties, and drains.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. FOG: Fats, oils, and greases.
- C. FRP: Fiberglass-reinforced plastic.
- D. HDPE: High-density polyethylene plastic.
- E. PE: Polyethylene plastic.
- F. PP: Polypropylene plastic.
- G. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

- A. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.
- B. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.

- C. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.
- D. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.
- E. Response to Specifications:
 - 1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
 - 2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.
 - 3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
 - 4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.
- F. Resubmittals Requirements:
 - 1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
 - 2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
 - 3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.
 - 4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.
- G. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.
- H. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. Specialties as specified in this section.
- I. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
 - 1. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."
- B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

- A. Exposed Metal Cleanouts:
 - 1. ASME A112.36.2M, Cast-Iron Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Josam Company; Josam Div.
 - 2) MIFAB, Inc.
 - 3) Smith, Jay R. Mfr. Co.
 - 4) Tyler Pipe; Wade Div.
 - 5) Watts Drainage Products Inc.
 - 6) Zurn Plumbing Products Group.
 - 2. ASME A112.3.1, Stainless-Steel Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 1) Josam Company.
 - 2) MIFAB, Inc.
3. Standard: ASME A112.36.2M for cast iron or ASME A112.3.1 for stainless steel for cleanout test tee.
 4. Size: Same as connected drainage piping
 5. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
 6. Closure: Countersunk, plug.
 7. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 8. Closure: Stainless-steel plug with seal.
- B. Metal Floor Cleanouts:
1. ASME A112.36.2M, Cast-Iron Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Josam Company.
 - 2) Oatey.
 - 3) Sioux Chief Manufacturing Co., Inc.
 - 4) Smith, Jay R. Mfg. Co.
 - 5) Tyler Pipe.
 - 6) Watts Drainage Products.
 - 7) Zurn Plumbing Products Group.
- C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfr. Co.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
 2. Standard: ASME A112.36.2M. Include wall access.
 3. Size: Same as connected drainage piping.
 4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 5. Closure: Countersunk, brass plug.
 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 7. Wall Access: Round, stainless steel cover plate with screw.
 8. Wall Access: Round, wall-installation frame and cover.

2.2 FLOOR DRAINS

- A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfr. Co.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products.
 - f. Zurn Plumbing Products Group.
2. Standard: ASME A112.6.3 with trap-guard.
3. Pattern: Floor, sanitary drain. Refer to drain schedule on drawings.
4. Body Material: Gray iron.
5. Seepage Flange: Required with waterproofing membranes.
6. Anchor Flange: Required.
7. Outlet: Bottom.
8. Coating on Interior and Exposed Exterior Surfaces: Galvanized where scheduled.
9. Sediment bucket where scheduled.
10. Top or Strainer Material: As scheduled.
11. Top of Body and Strainer Finish: As scheduled.
12. Top Shape: As scheduled.
13. Inlet Fitting: Gray iron, spigot or no-hub outlet, and trap-seal primer valve connection where required.
14. Trap Material: Cast iron.
15. Trap Features: Trap-seal primer valve drain connection where required.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ProSet Systems Inc.
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
 2. Size: Same as connected waste piping with increaser fitting of size indicated.
- B. Deep-Seal Traps:
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
 2. Size: Same as connected waste piping.
 - a. NPS 2: 4-inch- minimum water seal.
 - b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.
- C. Floor-Drain, Trap-Seal Primer Fittings:
1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
 2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals as prescribed in UPC for piping NPS 4 and smaller and 100 feet for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

- 3. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- E. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- G. Install trap guards in floor drains.
 - 1. Exception:
 - a. Kitchen wet areas.
 - b. Where trap priming devices are indicated.

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316.01 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."

- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.01

SECTION 221414 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Copper tube and fittings.
4. PVC pipe and fittings.
5. Specialty pipe fittings.

B. Related Sections:

1. Section 221429 "Sump Pumps" for storm drainage pumps.
2. Section 334000 "Storm Drainage Utilities" for storm drainage piping outside the building.

1.2 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water.
2. Storm Drainage, Force-Main Piping: 100 psig.

1.3 ACTION SUBMITTALS

A. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.

B. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.

C. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.

D. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.

E. Response to Specifications:

1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.

3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
 4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.
- F. Resubmittals Requirements:
1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
 2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
 3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.
 4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.
- G. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.
- H. Documents submitted shall show the following:
1. Detailed dimensions and details of construction.
- I. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.
- J. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.
- K. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.
- L. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.
- M. Response to Specifications:
1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
 2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.
 3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
 4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.
- N. Resubmittals Requirements:

1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
 2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
 3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.
 4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.
- O. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.
- P. Documents submitted shall show the following:
1. Detailed dimensions and details of construction.
- Q. Product Data: For each type of product indicated.
- R. LEED Submittals:
1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastics Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service classes.
- B. Gaskets: ASTM C 564, rubber.
- C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ANACO-Husky.
 - b. Clamp-All Corp.
 - c. Mission Rubber Company; a division of MCP Industries, Inc.
 - d. Tyler Pipe.
 - 2. Standards: ASTM C 1277 and ASTM C 1540.
 - 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

- A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight. Include square-cut-grooved or threaded ends matching joining method.
- B. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12 threaded.
- C. Steel-Pipe Pressure Fittings:
 - 1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Schedule 40, seamless steel pipe. Include ends matching joining method.
 - 2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - 3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- D. Cast-Iron Flanges: ASME B16.1, Class 125.
 - 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- E. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International, Inc.
 - b. Grinnell Mechanical Products.
 - c. Shurjoint Piping Products.
 - d. Victaulic Company.
2. Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 536 ductile-iron castings, ASTM A 47/A 47M malleable-iron castings, ASTM A 234/A 234M forged-steel fittings, or ASTM A 106/A 106M steel pipes with dimensions matching ASTM A 53/A 53M steel pipe, and complying with AWWA C606 for grooved ends.
3. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.5 DUCTILE-IRON PIPE AND FITTINGS

A. Ductile-Iron, Mechanical-Joint Piping:

1. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Ductile-Iron, Push-On-Joint Piping:

1. Ductile-Iron Pipe: AWWA C151/A21.51, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, push-on-joint ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. Gaskets: AWWA C111/A21.11, rubber.

C. Ductile-Iron, Grooved-Joint Piping:

1. Ductile-Iron Pipe: AWWA C151/A21.51 with round-cut-grooved ends according to AWWA C606.
2. Ductile-Iron-Pipe Appurtenances:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Anvil International, Inc.
 - 2) Shurjoint Piping Products.
 - 3) Victaulic Company.
 - b. Grooved-End, Ductile-Iron Fittings: ASTM A 536 ductile-iron castings with dimensions matching AWWA C110/A21.10 ductile-iron pipe or

AWWA C153/A21.53 ductile-iron fittings and complying with AWWA C606 for grooved ends.

- c. Grooved Mechanical Couplings for Ductile-Iron Pipe: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber center-leg gasket suitable for hot and cold water; and bolts and nuts.

2.6 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.
- C. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
- D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.
- E. Copper Pressure Fittings:
 - 1. Copper Fittings: ASME B16.18, cast-copper-alloy fittings or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 - 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.7 PVC PIPE AND FITTINGS

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
- C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- D. Adhesive Primer: ASTM F 656.
 - 1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. Solvent Cement: ASTM D 2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.8 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Non-pressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dallas Specialty & Mfg. Co.
 - 2) Mission Rubber Company; a division of MCP Industries, Inc.
 - 3) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
 - b. Standard: ASTM C 1173.
 - c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. Sleeve Materials:
 - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
4. Shielded, Non-pressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company; a division of MCP Industries, Inc.
 - b. Standard: ASTM C 1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
5. Pressure Transition Couplings:

- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Dresser, Inc.
 - 3) EBAA Iron, Inc.
 - 4) Ford Meter Box Company, Inc. (The).
 - 5) JCM Industries, Inc.
 - 6) Romac Industries, Inc.
 - 7) Smith-Blair, Inc.; a Sensus company.
 - 8) Viking Johnson; c/o Mueller Co.
 - b. Standard: AWWA C219.
 - c. Description: Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
 - d. Center-Sleeve Material: Galvanized carbon steel, stainless steel, ductile iron.
 - e. Gasket Material: Natural or synthetic rubber.
 - f. Metal Component Finish: Corrosion-resistant coating or material.
- B. Dielectric Fittings:
- 1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
 - 2. Dielectric Unions:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Capital Manufacturing Company.
 - 2) Central Plastics Company.
 - 3) Hart Industries International, Inc.
 - 4) Jomar International Ltd.
 - 5) Matco-Norca, Inc.
 - 6) McDonald, A.Y. Mfg. Co.
 - 7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 8) Wilkins; a Zurn company.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 150 psig at 180 deg F.
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous.
 - 3. Dielectric Flanges:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Capital Manufacturing Company.
 - 2) Central Plastics Company.

- 3) Matco-Norca, Inc.
 - 4) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 5) Wilkins; a Zurn company.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.
 - 3) Pressure Rating: 150 psig.
 - 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
4. Dielectric-Flange Insulating Kits:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Advance Products & Systems, Inc.
 - 2) Calpico, Inc.
 - 3) Central Plastics Company.
 - 4) Pipeline Seal and Insulator, Inc.
 - b. Description:
 - 1) Non-conducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig.
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel-backing washers.
5. Dielectric Nipples:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Elster Perfection.
 - 2) Grinnell Mechanical Products.
 - 3) Matco-Norca, Inc.
 - 4) Precision Plumbing Products, Inc.
 - 5) Victaulic Company.
 - b. Description:
 - 1) Electroplated steel nipple complying with ASTM F 1545.
 - 2) Pressure Rating: 300 psig at 225 deg F.
 - 3) End Connections: Male threaded or grooved.
 - 4) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312200 "Earthwork."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- K. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow.
- L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- M. Install steel piping according to applicable plumbing code.
- N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- O. Install force mains at elevations indicated.

- P. Plumbing Specialties:
 - 1. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 221423.01 "Storm Drainage Piping Specialties."
 - 2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 221423.01 "Storm Drainage Piping Specialties."
- Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- R. Install sleeve seals for piping penetrations of concrete walls and slabs above slab on grade. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- S. Install escutcheons for piping penetrations of walls, ceilings, and raised floors above slab on grade. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub-and-Spigot, Cast-Iron Soil Piping Calked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.
- C. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- F. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- G. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
- H. Plastic, Non-pressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Shielded, non-pressure transition couplings.
3. In Aboveground Force-Main Piping: Fitting-type transition couplings.
4. In Underground Force-Main Piping:
 - a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
 - b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

- A.** General valve installation requirements are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- B.** Shutoff Valves: Install shutoff valve on each sump pump discharge.
1. Install gate or full-port ball valve for piping NPS 2 and smaller.
 2. Install gate valve for piping NPS 2-1/2 and larger.
- C.** Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

- A.** Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 6. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

- c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
- 7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 - 5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
 - 6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 - 3. NPS 2: 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 - 5. NPS 3: 12 feet with 1/2-inch rod.
 - 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 - 7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
 - 8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.
- H. Install supports for vertical steel piping every 15 feet.
- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 - 5. NPS 6: 10 feet with 5/8-inch rod.
 - 6. NPS 8: 10 feet with 3/4-inch rod.
- J. Install supports for vertical copper tubing every 10 feet.
- K. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
 2. NPS 3: 48 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
 4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.
 5. NPS 10 and NPS 12: 48 inches with 7/8-inch rod.
- L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.
1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
 2. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.
 3. Comply with requirements for backwater valves, cleanouts and drains specified in Section 221423.13 "Storm Drainage Piping Specialties."
- D. Connect force-main piping to the following:
1. Storm Sewer: To exterior force main.
 2. Sump Pumps: To sump pump discharge.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- F. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

- A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 5. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 4. Prepare reports for tests and required corrective action.

3.10 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping NPS 6 and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 - 3. Galvanized-steel pipe, drainage fittings, and threaded joints.
 - 4. Copper DWV tube, copper drainage fittings, and soldered joints.
 - 5. Schedule 40 PVC pipe with socket weld pipe fittings for garage structure only.
 - 6. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- C. Aboveground, storm drainage piping NPS 10 and larger shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 - 3. Solid wall PVC socket fittings and solvent cemented joints for structure only.
- D. Aboveground storm drainage piping NPS 12 and larger:
 - 1. Service class cast iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Solid wall PVC pipe, PVC socket fittings and solvent cemented joints. For garage structure only.
- E. Aboveground storm drainage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
 - 1. Hard copper tube, copper pressure fittings, and soldered joints.
 - 2. Galvanized-steel pipe, pressure fittings, and threaded joints.
- F. Aboveground storm drainage force mains NPS 2-1/2 to NPS 6 shall be any of the following:
 - 1. Hard copper tube, copper pressure fittings, and soldered joints.
 - 2. Galvanized-steel pipe, pressure fittings, and threaded joints.
 - 3. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
 - 4. Fitting-type transition couplings if dissimilar pipe materials.

END OF SECTION 221414

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Roof drains.
 - 2. Miscellaneous storm drainage piping specialties.
 - 3. Cleanouts.
 - 4. Backwater valves.
 - 5. Through-penetration firestop assemblies.
 - 6. Flashing materials.

1.3 ACTION SUBMITTALS

- A. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.
- B. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.
- C. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.
- D. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.
- E. Response to Specifications:
 - 1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
 - 2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.
 - 3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
 - 4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.

- F. Resubmittals Requirements:
 - 1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
 - 2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
 - 3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.
 - 4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.
- G. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.
- H. Documents submitted shall show the following:
 - 1. Detailed dimensions and details of construction.
- I. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

- A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. Marathon Roofing Products.
 - c. MIFAB, Inc.
 - d. Smith, Jay R. Mfg. Co.
 - e. Tyler Pipe.
 - f. Watts; a division of Watts Water Technologies, Inc.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.6.4, for general-purpose roof drains.
 - 3. Body Material: Cast iron.
 - 4. Dimension of Body: Nominal 14-inch diameter.
 - 5. Combination Flashing Ring and Gravel Stop: Where required.
 - 6. Flow-Control Weirs: Not required.

7. Outlet: Bottom.
8. Extension Collars: Required as needed.
9. Underdeck Clamp: On metal decks.
10. Expansion Joint: Not required.
11. Sump Receiver Plate: On metal decks.
12. Dome Material: Aluminum.
13. Perforated Gravel Guard: Stainless steel, on built-up roofs.
14. Vandal-Proof Dome: Not required.
15. Water Dam: 2 inches high.

2.2 CLEANOUTS

A. Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. Oatey.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.
 - e. Tyler Pipe.
 - f. Watts Water Technologies, Inc.
 - g. Zurn Plumbing Products Group; Light Commercial Products Operation.
 - h. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for threaded, adjustable housing cleanouts.
3. Size: Same as connected branch.
4. Type: Adjustable housing Threaded, adjustable housing.
5. Body or Ferrule Material: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with set-screws or other device.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top-Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk or raised head, brass.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hubless, cast-iron soil-pipe test tee or as required to match connected piping.
5. Closure: Countersunk or raised-head, drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Round, stainless steelwall-installation frame and cover.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ProSet Systems Inc.
2. Standard: ASTM E 814, for through-penetration firestop assemblies.
3. Certification and Listing: Intertek Testing Service NA for through-penetration firestop assemblies.
4. Size: Same as connected pipe.
5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Special Coating: Corrosion resistant on interior of fittings.

2.4 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft..
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 - 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 - 2. Install expansion joints, if indicated, in roof drain outlets.
 - 3. Position roof drains for easy access and maintenance.
- B. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate cleanouts at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install test tees in vertical conductors and near floor.
- F. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

- G. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- H. Assemble channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
- I. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.
- J. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 FLASHING INSTALLATION

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Oil-sensing sump pumps and controllers..

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Oil-sensing sump pumps and controllers.
- B. Product Data Submittals: For each product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles.
 - 2. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. Shop Drawings:
 - 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. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps and controls.
 - 1. Indicate actual installed items by marking submittals with an arrow or box.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with manufacturer's written instructions for handling.

1.5 WARRANTY

- A. Manufacturer Warranty: Manufacturer and Installer agree to repair or replace sump pumps that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Faulty operation
 - b. Deterioration of metals, metal finishes, and other materials beyond normal **use**.
 2. Warranty Period: 1 year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OIL-SENSING SUMP PUMPS AND CONTROLLERS

- A. Oil-Sensing Sump Pumps and Controllers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Stancor
 - b. Grundfos Pumps Corp.
 - c. ITT Flygt Corporation.
 - d. Weil Pump Company, Inc.
 2. Description: Factory-assembled and -tested sump-pump unit. ASME A17.1 compliant.
 3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 14.1-14.2 and HI 14.3.
 4. Pump Casing: Cast iron, with strainer inlet; legs that elevate pump to permit flow into impeller; and vertical discharge for piping connection.
 5. Capacities and Characteristic:
 - a. See pump schedule on drawings.
 6. Controls:
 - a. Industrial-grade switch(es) with internal 20 A relay and Type 304 stainless steel sensor probes.
 - b. Liquid/oil sensor that differentiates and indicates the presence of oil and/or water under high-water conditions.
 - c. Alarm Panel:
 - 1) High-oil-level alarm.
 - 2) High-water-level alarm.
 - 3) Audible and visual alarms for each alarm condition.
 - 4) Dry contacts for remote monitoring of oil, water, and high liquid conditions.
 - d. Control Panel:
 - 1) Simplex
 - 2) Enclosure: NEMA 250, Type 4X.
 - 3) HOA switch(es).

- 4) Green pump run light; power on light.
- 5) Pump circuit breaker(s).

PART 3 - EXECUTION

END OF SECTION 221429

SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Commercial, electric, storage, domestic-water heaters.
 - 2. Domestic-water heater accessories.

1.2 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:
 - 1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.
- B. Product Certificates: For each type of commercial residential and tankless , electric, domestic-water heater.
- C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electric, domestic-water heaters to include emergency, operation, and maintenance manuals.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Electric, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Three Five <Insert number> years.
 - 2) Controls and Other Components: Three Five <Insert number> years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B. Seismic Performance: Commercial, electric, domestic-water heaters to withstand the effects of earthquake motions determined in accordance with 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 ."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

- A. Commercial, Electric, Storage, Domestic-Water Heaters:
 - 1. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
 - 2. Standard: UL 1453.
 - 3. Storage-Tank Construction: Non- ASME-code, steel horizontal vertical arrangement.
 - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

- 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.
- b. Pressure Rating: **150 psig**.
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tapings.
4. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - c. Insulation: Comply with ASHRAE/IES 90.1.
 - d. Jacket: Steel with enameled finish or high-impact composite material.
 - e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - f. Temperature Control: Adjustable thermostat.
 - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
5. Special Requirements: NSF 5 construction.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. Source Limitations: Obtain domestic-water expansion tanks from single source from single manufacturer.
2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
4. Capacity and Characteristics:
 - a. Working-Pressure Rating: **100 psig 150 psig** <Insert value>.
 - b. Capacity Acceptable: **2 gal. 4 gal. 7 gal. 10 gal.** <Insert value> minimum.
 - c. Air Precharge Pressure: <Insert system pressure>.

- B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than **NPS 3/4** with ASME B1.20.1 pipe threads.
- C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1 ASHRAE 90.2 .
- D. Heat-Trap Fittings: ASHRAE/IES 90.1 ASHRAE 90.2 .
- E. Manifold Kits: Domestic-water-heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and calibrated memory-stop balancing valves to provide balanced flow through each domestic-water heater.
 - 1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
 - 2. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."
- F. Pressure-Reducing Valves: ASSE 1003 for water. Set at **25-psig-** maximum outlet pressure unless otherwise indicated.
- G. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
- H. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.
- I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
- J. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.
- K. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of **18 inches** <Insert dimension> above the floor.
- L. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test **commercial** domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 2. Maintain manufacturer's recommended clearances.
 3. Arrange units so controls and devices that require servicing are accessible.
 4. 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.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 8. Anchor domestic-water heaters to substrate.
- B. Residential, Electric, Domestic-Water Heater Mounting: Install residential, electric, domestic-water heaters on floor on water-heater stand on floor on domestic-water heater mounting bracket .
1. Maintain manufacturer's recommended clearances.
 2. Arrange units so controls and devices that require servicing are accessible.
 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.
 5. Anchor domestic-water heaters to substrate.
- C. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least **18 inches** above floor on wall bracket.
1. Maintain manufacturer's recommended clearances.
 2. Arrange units so controls and devices that require servicing are accessible.
 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.
 5. Anchor domestic-water heaters to substrate.
- D. Install electric, domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."

- E. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment." Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- F. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- G. Install **combination temperature-and-** pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- H. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."
- I. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- J. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- K. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping" and comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."
- L. Install pressure-reducing valve with integral bypass relief valve in electric, domestic-water booster-heater inlet piping and water hammer arrester in booster-heater outlet piping. Set pressure-reducing valve for outlet pressure of **25 psig** <Insert value>. Comply with requirements for pressure-reducing valves and water hammer arresters specified in Section 221119 "Domestic Water Piping Specialties."
- M. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
- N. Fill electric, domestic-water heaters with water.
- O. Charge domestic-water expansion tanks with air to required system pressure.
- P. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water to contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. 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 tests and inspections with the assistance of a factory-authorized service representative .
- D. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 223300

SECTION 224200 - COMMERCIAL PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Commercial lavatories.
 - 2. Commercial showers.
 - 3. Commercial sinks.
 - 4. Commercial urinals.
 - 5. Commercial water closets.
 - 6. Flushometer valves.
 - 7. Toilet seats.
 - 8. Fixture carriers.

1.2 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.
- B. High-Efficiency Flush Volume: 1.28 gal. or less per flush.
- C. PMMA: Polymethyl methacrylate; also known as "acrylic."
- D. Standard-Efficiency Flush Volume: 1.6 gal. per flush.
- E. WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Include construction details, material descriptions and thicknesses, dimensions of individual components and profiles, and finishes for plumbing fixtures.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Plans, elevations, sections, and mounting details.
 - 2. Details of equipment assemblies, including accessories. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, location and size of each field connection, location and size of each cutout, and anchorage provisions and attachment methods. Indicate coordination requirements for adjacent and interfacing Work.
 - 3. Diagrams for power, signal, and control wiring.

- C. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories and/or counter-mounted sinks.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
1. For lavatories and faucets.
 - a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1) Servicing and adjustments of automatic faucets.
 2. For shower valves to include in maintenance manuals.
 3. For sinks and faucets to include in operation and maintenance manuals.
 - a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1) Servicing and adjustments of automatic faucets.
 4. For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
 3. Shower Valve Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 4. Shower Valve Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
 5. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Lavatory faucets, sink faucets, shower valves intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 COMMERCIAL LAVATORIES

A. Lavatories, Counter Mounted:

1. Lavatories, Undercounter Mounted - Vitreous China, Oval :

a. Fixture:

- 1) Standard: ASME A112.19.2/CSA B45.1.
- 2) Type: For undercounter mounting.
- 3) Nominal Size: Oval, **as indicated on Drawings.**
- 4) Faucet-Hole Punching: No holes.
- 5) Faucet-Hole Location: On countertop.
- 6) Color: White.
- 7) Mounting Material: Sealant and undercounter mounting kit.

b. Faucet: Lavatory Faucets, Automatically Operated.

B. Lavatories, Wall Mounted:

1. Lavatories, Wall Mounted - Vitreous China, Rectangular with Back :

a. Fixture:

- 1) Standard: ASME A112.19.2/CSA B45.1.
- 2) Type: For wall hanging.
- 3) Nominal Size: Rectangular, as indicated on Drawings.
- 4) Faucet-Hole Punching: As required for specified faucet.
- 5) Faucet-Hole Location: Top.
- 6) Color: White.
- 7) Mounting Material: Lavatory carrier.

b. Faucet: Lavatory Faucets, Automatically Operated.

- c. Support: Lavatory carrier, floor affixed with steel uprights, concealed arm.
- d. Lavatory Mounting Height: Accessible in accordance with ICC A117.1.

C. Lavatory Faucets, Automatically Operated :

1. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.

2. Operation Type: Hardwired electronic sensor operated with battery backup.
3. 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.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
5. Body Type: Single hole.
6. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
7. Finish: Polished chrome plate.
8. Maximum Flow Rate: **0.5 gpm.**
9. Mounting Type: Deck, concealed.
10. Spout: Rigid, gooseneck type.
11. Spout Outlet: Laminar flow.
12. Drain: Not part of faucet.

D. Lavatory Supply Fittings:

1. NSF Standards: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
2. Standard: ASME A112.18.1/CSA B125.1.
3. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless steel wall flange.
4. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
5. Operation: Loose key.
 - a. Risers Size: **NPS 3/8.**
 - b. Risers Material: ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel, flexible hose.

E. Lavatory Waste Fittings:

1. Standard: ASME A112.18.2/CSA B125.2.
2. Drain: Grid type with **NPS 1-1/4** offset and straight tailpiece.
3. Trap:
 - a. Size: **NPS 1-1/2 by NPS 1-1/4.**
 - b. Material:
 - 1) Chrome-plated, brass or steel wall flange.

2.3 COMMERCIAL SHOWERS

A. Showers Valve Assemblies:

1. Shower Valve Assemblies - Single-Handle, Pressure-Balanced Mixing Valve with Head :
 - a. Description: Single-handle, pressure-balance mixing valve with hot- and cold-water indicators; check stops; and shower head.
 - b. Shower Valve:
 - 1) Standards:

- a) ASME A112.18.1/CSA B125.1.
- b) ASSE 1016/ASME A112.1016/CSA B125.16.
- 2) Body Material: Solid brass.
- 3) Finish: Polished chrome plate.
- 4) Mounting: Concealed.
- 5) Operation: Single-handle, rotate control.
- 6) Antiscald Device: Integral with mixing valve.
- 7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
- c. Supply Connections: **NPS 1/2**.
- d. Shower Head:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Type: Ball joint with arm and flange.
 - 3) EPA WaterSense: Required.
 - 4) Shower Head Maximum Flow Rate: **1.5 gpm**.
 - 5) Shower Head Material: Metallic with chrome-plated finish.
 - 6) Spray Pattern: Fixed.
 - 7) Integral Volume Control: Not required.
 - 8) Temperature Indicator: Not required.
 - 9)

B. Shower Basins:

1. Shower Basins - Cast Polymer :

- a.
- b. Source Limitations: Obtain shower basins from single source from single manufacturer.
- c. Description: Cast-polymer base for built-up-type shower fixture.
- d. Standard: CSA B45.5/IAPMO Z124.
- e. Type: Accessible in accordance with ICC A117.1.
- f. Nominal Size and Shape: As indicated on Drawings.
- g. Color: White .
- h. Outlet: Drain with **NPS 2** outlet.

C. Grout:

- 1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- 2. Characteristics: Nonshrink; recommended for interior and exterior applications.
- 3. Design Mix: **5000 psi**, 28-day compressive strength.
- 4. Packaging: Premixed and factory packaged.

2.4 COMMERCIAL SINKS

A. Service Sinks, Floor Mounted:

1. Service Sinks, Floor Mounted - Terrazzo:

- a. Source Limitations: Obtain sinks from single source from single manufacturer.

- b. Fixture:
 - 1) Material: Marble chips cast in portland cement to produce a compressive strength of not less than **3000 psi**, seven days after casting.
 - 2) Shape: as indicated on plans.
 - 3) Nominal Size: **24 by 24 inches**.
 - 4) Height: **12 inches** with dropped front.
 - 5) Tiling Flange: as indicated on plans.
 - 6) Rim Guard: On all top surfaces.
 - 7) Color: Not applicable.
 - 8) Drain: Grid with **NPS 3** outlet.
- c. Mounting: On floor and flush to wall.
- d. Faucet: Service Sink Faucets, Manually Operated.

B. Breakroom / Mothers room Sinks:

1. Breakroom / Mothers room, Counter Mounted - Stainless Steel :

- a. Source Limitations: Obtain sinks from single source from single manufacturer.
- b. Fixture:
 - 1) Standard: ASME A112.19.3/CSA B45.4.
 - 2) Type: Stainless steel, self-rimming, sound-deadened unit less ledge back.
 - 3) Number of Compartments: One.
 - 4) Overall Dimensions: .
 - 5) Material: 18 gauge, Type 304 stainless steel.
 - 6) Compartment:
 - a) Dimensions: .
 - b) Drain: Grid with **NPS 1-1/2** tailpiece and twist drain.
 - c) Drain Location: Centered in compartment.
 - d) Depth: Standard.
- c. Faucet(s): Sink Faucets, Manually Operated.
 - 1) Number Required: One.
 - 2) Mounting: On ledge.
- d. Supply Fittings:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
 - a) Operation: Loose key.
 - b) Risers: **NPS 1/2**, chrome-plated,- rigid-copper pipe
- e. Waste Fittings:
 - 1) Standard: ASME A112.18.2/CSA B125.2.
 - 2) Trap(s) Size: **NPS 1-1/2**.
 - 3) Trap(s) Material:

- a) Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall; and chrome-plated brass or steel wall flange.
 - f. Mounting: On counter with sealant.
- C. Sink Faucets, Manually Operated:
- 1. Sink Faucets, Manually Operated : Single control, mixing.
 - a. Source Limitations: Obtain sink faucets from single source from single manufacturer.
 - b. Standards:
 - 1) ASME A112.18.1/CSA B125.1.
 - 2) NSF 61.
 - 3) NSF 372.
 - c. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
 - d. Body Type: Single hole.
 - e. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
 - f. Finish: Polished chrome plate.
 - g. Maximum Flow Rate: 1.5 gpm .
 - h. Mounting Type: Deck, concealed .
 - i. Spout Type: Rigid, gooseneck .
 - j. Vacuum Breaker Not required for hose outlet.
 - k. Spout Outlet: Laminar flow.
 - 2. Sink Faucets, Manually Operated - Service Sink :
 - a. Source Limitations: Obtain sink faucets from single source from single manufacturer.
 - b. Description: Wall/back mounted, brass body, with integral service stops, checks, spout with bucket/pail hook, 3/4-inch hose thread end, integral vacuum breaker, inlets 8 inches o.c., and two-handle mixing.
 - c. Faucet:
 - 1) Standards:
 - a) ASME A112.18.1/CSA B125.1.
 - b) NSF 61 and NSF 372.
 - c) ICC A117.1.
 - d) ASSE 1001 (VB).
 - 2) Finish: Polished chrome plated .
 - 3) Handles: Lever.
 - 4) Cartridges: Ceramic.
 - 5) Brace: Adjustable top brace.
 - d. Vacuum Breaker: Required for hose outlet.
 - e. Spout Outlet: Hose thread in accordance with ASME B1.20.7.

D. Sink Supply Fittings:

1. NSF Standards: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
2. Standard: ASME A112.18.1/CSA B125.1.
3. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless steel wall flange.
4. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
5. Operation: Loose key.
 - a. Risers Sizes: **NPS 1/2**.
 - b. Risers Material: Chrome-plated, rigid-copper pipe.

E. Sink Waste Fittings:

1. Standard: ASME A112.18.2/CSA B125.2.
2. Drain: Grid type with **NPS 1-1/2** offset and straight tailpiece.
3. Trap:
 - a. Size: **NPS 1-1/2**.
 - b. Material: Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall and chrome-plated brass or steel wall flange.

F. Grout:

1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink; recommended for interior and exterior applications.
3. Design Mix: **5000 psi**, 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

2.5 COMMERCIAL URINALS

A. Urinals, Wall Hung - Back Outlet, Washdown :

- a. Fixture:
 - 1) Standards:
 - a) ASME A112.19.2/CSA B45.1.
 - b) ASME A112.19.5/CSA B45.15.
 - 2) Material: Vitreous china.
 - 3) Type: Washdown with extended shields.
 - 4) Strainer or Trapway: Manufacturer's standard strainer with integral trap.
 - 5) Water Consumption: **0.125 gpf**.
 - 6) Spud Size and Location: **NPS 3/4**, top.
 - 7) Outlet Size and Location: **NPS 2**, back.
 - 8) Color: White.
- b. Flushometer Valve: Flushometer Valves, Exposed, Sensor Operated.
- c. Waste Fitting:

- 1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
- 2) Size: **NPS 2**.
- d. Support: Urinal carrier, floor affixed with steel uprights with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
- e. Urinal Mounting Height: Accessible in accordance with ICC A117.1 where required; Standard height for remaining fixtures..

2.6 COMMERCIAL WATER CLOSETS

A. Water Closets, Wall Mounted:

1. Water Closets, Wall Mounted - Top Spud :

- a. Source Limitations: Obtain water closets from single source from single manufacturer.
- b. Standard: ASME A112.19.2/CSA B45.1.
- c. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Mounting Height: Accessible in accordance with ICC A117.1, where required; Standard height for remaining fixtures.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: **1.1 gal** per flush.
 - 7) Spud Size and Location: **NPS 1-1/2**; top.
 - 8) Color: White.
- d. Flushometer Valve. Sensor Operated - Piston, Hardwired..
- e. Toilet Seat: Commercial.
- f. Support: Water-closet carrier, floor affixed.

2.7 FLUSHOMETER VALVES

A. Flushometer Valves, Sensor Operated:

1. Flushometer Valves, Sensor Operated - Piston, Hardwired :

- a. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
- b. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
- c. Minimum Pressure Rating: **125 psig**.
- d. Features: Include integral check stop and backflow-prevention device.
- e. Material: Brass body with corrosion-resistant components.
- f. Style: Exposed.
- g. Exposed Flushometer-Valve Finish: Chrome-plated.
- h. Panel Finish: Chrome-plated or stainless steel.
- i. Trip Mechanism: Hardwired, control-voltage electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
- j. Consumption: **.0125 gal** per flush.

- k. Minimum Inlet: **NPS 1.**
- l. Minimum Outlet: **NPS 1-1/4.**

2.8 TOILET SEATS

A. Toilet Seats - Commercial :

- 1. Source Limitations: Obtain toilet seat from single source from single manufacturer.
- 2. Standard: IAPMO/ANSI Z124.5.
- 3. Material: Plastic.
- 4. Type: Commercial (heavy duty).
- 5. Shape: Elongated rim, open front.
- 6. Hinge: Self-sustaining, check.
- 7. Hinge Material: Noncorroding metal.
- 8. Seat Cover: Required.
- 9. Color: White .
- 10. Surface Treatment: Not required.

2.9 FIXTURE CARRIERS

A. Fixture Carriers - Lavatory :

- 1. Source Limitations: Obtain lavatory carriers from single source from single manufacturer.
- 2. Standards:
 - a. ASME A112.6.1M.
 - b. ASME A112.6.2..

B. Fixture Carriers - Urinal :

- 1.
- 2. Source Limitations: Obtain urinal carriers from single source from single manufacturer.
- 3. Standard: ASME A112.6.1M.
- 4. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture.

C. Fixture Carriers - Water Closet :

- 1.
- 2. Source Limitations: Obtain water closet carriers from single source from single manufacturer.
- 3. Standard: ASME A112.6.1M.
- 4. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- B. Examine walls and floors for suitable conditions where plumbing fixtures will be installed.
- C. Examine counters for suitable conditions where lavatories and sinks will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF COMMERCIAL PLUMBING FIXTURES

A. Lavatory Installation:

- 1. Install lavatories level and plumb in accordance with roughing-in drawings.
- 2. Install supports, affixed to building substrate, for wall-mounted lavatories.
- 3. Install accessible, wall-mounted lavatories at mounting height in accordance with ICC A117.1.
- 4. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
- 5. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
- 6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
- 7. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- 8. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

B. Shower Installation:

- 1. Assemble shower components in accordance with manufacturers' written instructions.
- 2. Install showers level and plumb in accordance with roughing-in drawings.
- 3. Install ball valves in water-supply piping to the shower if supply stops are specified with the shower valve. Comply with ball valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping." Install valves in locations that are accessible for ease of operation.
- 4. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- 5. Set shower basins in leveling bed of cement grout.
- 6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
- 7. Showers, except Cast-Polymer Showers: Seal joints between showers, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to

fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

8. Cast-Polymer Showers: Adhere panels to drywall using shower manufacturer's recommended adhesive. Seal joints, between panels and between panels and adjacent drywall, using shower manufacturer's recommended caulking specific for each application. Match sealant to fixture color.

C. Sink Installation:

1. Install sinks level and plumb in accordance with roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted sinks.
3. Install accessible, wall-mounted sinks at mounting height in accordance with ICC A117.1.
4. Set floor-mounted sinks in leveling bed of cement grout.
5. Install water-supply piping with stop on each supply to each sink faucet.
 - a. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping."
 - b. Install stops/valves in locations that are accessible for ease of operation.
6. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
7. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
8. Seal joints between sinks, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
9. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

D. Urinal Installation:

1. Install urinals level and plumb in accordance with roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste-fitting seals and attached to supports.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
5. Measure support height installation from finished floor, not structural floor.
6. Install flushometer-valve, water-supply fitting on each supply to each urinal.
7. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
8. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
9. Install actuators in locations easily reachable for people with disabilities.
10. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
11. Seal joints between urinals, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to urinal color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

E. Water Closet Installation:

1. Install water closets level and plumb in accordance with roughing-in drawings.
2. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals, and affix to building substrate.
3. Measure support height installation from finished floor, not structural floor.
4. Install flushometer-valve, water-supply fitting on each supply to each water closet.
5. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
6. Install actuators in locations easily reachable for people with disabilities.
7. Install toilet seats on water closets.
8. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
9. Seal joints between water closets, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 INSTALLATION OF PIPING CONNECTIONS

- A. Connect plumbing fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match plumbing fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil, waste, and vent piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible plumbing fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- E. Where installing piping adjacent to water closets and urinals, allow space for service and maintenance.

3.4 INSTALLATION OF ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch** high.

3.5 INSTALLATION OF CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning plumbing fixtures, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Adjust water pressure at shower valves to produce proper flow.
- D. Adjust water pressure at flushometer valves to produce proper flow.
- E. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.7 CLEANING AND PROTECTION

- A. After completing installation of plumbing fixtures, inspect and repair damage to finishes. Replace any fixtures unable to be repaired to the satisfaction of the Architect and Owner.
- B. Clean plumbing fixtures and associated faucets, valves, flushometer valves, and fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and associated faucets, valves, flushometer valves, and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224200

SECTION 224700 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Drinking fountains.
 - 2. Bottle filling stations.
 - 3. Fixture carriers.

1.2 ACTION SUBMITTALS

- A. Submittals shall comply with Division 01 requirements and also comply with additional requirements indicated in this Section.
- B. Shop drawings shall indicate where the shop drawings were prepared and by who, with contact information including phone number and e-mail address.
- C. Submittal sheets shall be sequentially numbered with the format: sheet number of number total. For example, 1 of 3.
- D. Submit catalogs, brochures, product data and shop drawings that contain only information specific to equipment, products and materials to be furnished. Do not submit information that describes several different items or options other than those items or options to be used unless irrelevant information is marked out and relevant material is clearly marked.
- E. Response to Specifications:
 - 1. Manufacturer and Contractor shall submit a point by point statement of compliance with specifications.
 - 2. Where proposing to comply fully with stated requirement, indicate by placing the word "Comply" next to specification subparagraph text.
 - 3. Where proposing not to comply, or accomplish stated requirement in a manner different from that described, provide a full description of the deviation with a cross reference next to specification subparagraph text.
 - 4. Submittals which do not include a point by point statement of compliance as specified shall be rejected.
- F. Resubmittals Requirements:
 - 1. Provide at the front of the resubmittal a written response following each of the previous submittal review comments.
 - 2. Clearly identify each change by cloud, or other highly visible method, that draws attention to each change to the previous submittal.
 - 3. Mark each change on each page. Identify each new resubmittal page as "New Page" and mark through pages previously submitted that are no longer relevant. Do not remove previously submitted pages that are no longer relevant.

- 4. Only those changes that are clearly identified will be reviewed and considered part of the resubmittal. Changes that are not clearly identified will be ignored and not considered relevant.
- G. Before shop drawings and brochures are submitted for approval, confirm that each separate drawing or each item of equipment complies with the drawings and specifications.
- H. Product Data: For each type of pressure water cooler.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- I. LEED Submittals:
 - 1. Product Data for Prerequisite WE 1: Documentation indicating flow and consumption requirements.

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For Drinking fountains to include in maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filter Cartridges: Equal to 10 percent of quantity installed for each type and size indicated.

PART 2 - PRODUCTS

2.1 DRINKING FOUNTAINS

- A. Drinking fountains: Semi-recessed, wheelchair accessible with filter.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Elkay Manufacturing Co.
 - b. Halsey Taylor.
 - c. Haws Corporation.
 - d. Filtrine.
 - 2. Standards:
 - a. All components associated with distribution systems shall be lead free in accordance with the 2014 Safe Drinking Act (Sec. 1417), latest amendments and with applicable state regulations.

DRINKING FOUNTAINS AND WATER COOLERS

- b. Comply with NSF 61.
 - c. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
 - d. Comply with ICC A117.1.
- 3. Cabinet: All stainless steel with No. 4 satin finish with stainless-steel top.
 - 4. Bubbler: One, with adjustable stream regulator, located on deck.
 - 5. Control: Push button, easy tool.
 - 6. Drain: Grid with NPS 1-1/4 tailpiece.
 - 7. Supply: NPS 3/8 with shutoff valve.
 - 8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
 - 9. Filter: One or more filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - 10. Cooling System: Electric, with pre-cooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 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.
 - 11. Capacities and Characteristics:
 - a. Cooled: 6 gph.
 - b. Ambient-Air Temperature: 90 deg F.
 - c. Inlet- Temperature: 80 deg F.
 - d. Cooled- Temperature: 50 deg F.
 - e. Electrical Characteristics:
 - 1) Motor Horsepower: 1/5.
 - 2) Volts: 120-V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60.
 - 12. Support: Mounting frame or brackets for attaching to substrate.
 - 13. Provide units with heating devices for exterior coolers.
 - 14. Refer to schedule for Basis of Design.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for -supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Install mounting frames, affixed to building construction, and attach recessed, Drinking fountains to mounting frames.
- C. Install -supply piping with shutoff valve on supply to each fixture to be connected to domestic-distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- F. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect fixtures with supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with piping requirements specified in Section 221116 "Domestic Piping."
- C. Install ball valve on supply to each fixture. Install valve upstream from filter for cooler. Comply with valve requirements specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust pressure -cooler temperature settings.

3.5 CLEANING

- A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.

- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224700

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Support and attachment components.

1.2 RELATED REQUIREMENTS

- A. Section 230548 - Vibration and Seismic Controls for HVAC.

1.3 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping; 2025.
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- F. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates; 2024.
- G. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2022).
- H. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- I. FM (AG) - FM Approval Guide; Current Edition.
- J. MFMA-4 - Metal Framing Standards Publication; 2004.
- K. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.
- L. UL (DIR) - Online Certifications Directory; Current Edition.
- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of _____. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 4. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
 - 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Prefabricated Trapeze-Framed Metal Strut Systems:
 - 1. Strut Channel or Bracket Material:
 - 2. Accessories: Provide bracket covers, cable basket clips, cable tray clips, clamps, conduit clamps, fire-retarding brackets, j-hooks, protectors, and vibration dampeners.
- C. Hanger Rods:
 - 1. Threaded zinc-plated steel unless otherwise indicated.
- D. Steel Cable:
 - 1. Manufacturers:

- a. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
- E. Pipe Supports:
- 1. Manufacturers:
 - a. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
 - 3. Liquid Temperatures Up To 122 degrees F (50 degrees C):
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
 - b. Support From Below: MSS SP-58 Types 35 through 38.
- F. Beam Clamps:
- 1. Manufacturers:
 - a. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
 - 3. Beam C-Clamp: MSS SP-58 type 23, malleable iron and steel with plain, stainless steel, and zinc finish.
 - 4. Small or Junior Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish. For inverted usage provide manufacturer listed size(s).
 - 5. Wide Mouth Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish.
 - 6. Centerload Beam Clamp with Extension Piece: MSS SP-58 type 30, malleable iron with plain finish.
 - 7. FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58 type 19, plain finish.
 - 8. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
 - 9. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
- G. Pipe Hangers:
- 1. Split Ring Hangers:
 - a. Manufacturers:
 - 1) Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - b. Provide hinged split ring and yoke roller hanger with epoxy copper or plain finish.
 - c. Material: ASTM A47/A47M malleable iron or ASTM A36/A36M carbon steel.
 - d. Provide hanger rod and nuts of the same type and material for a given pipe run.
 - e. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
- H. Anchors and Fasteners:
- 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
 - 2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
 - 3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
 - 4. Hollow Masonry: Use toggle bolts.
 - 5. Hollow Stud Walls: Use toggle bolts.

6. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- C. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- D. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- E. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F. Equipment Support and Attachment:
 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- G. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- H. Secure fasteners according to manufacturer's recommended torque settings.
- I. Remove temporary supports.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Vibration-isolated equipment support bases.
- C. Vibration isolators.

1.2 REFERENCE STANDARDS

- A. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; Most Recent Edition Cited by Referring Code or Reference Standard.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATION REQUIREMENTS

- A. Provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections to vibration-isolated equipment.
- B. Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:
- C. General Requirements:
 - 1. Select vibration isolators to provide required static deflection.
 - 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
- D. Piping Isolation:

1. Provide vibration isolators for piping supports:
 - a. Located in equipment rooms.
2. Suspended Piping, Nonseismic Applications: Use spring isolator hangers or combination resilient material/spring isolator hangers.
3. Use modular seal or approved resilient material where vibration-isolated piping penetrates building elements (e.g., walls, floors) arranged to prevent vibration transmission to structure.

2.2 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

A. Manufacturers:

1. Vibration-Isolated Equipment Support Bases:
2. Source Limitations: Furnish vibration-isolated equipment support bases and associated components and accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.

B. Vibration-Isolated Structural Steel Bases:

1. Description: Engineered structural steel frames with integral mounting provisions for vibration isolators, sized and configured for mounting of equipment.
2. Color code or otherwise identify springs to indicate load capacity.
3. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.

2.3 VIBRATION ISOLATORS

A. Manufacturers:

1. Vibration Isolators:
2. Source Limitations: Furnish vibration-isolators and associated accessories produced by a single manufacturer and obtained from a single supplier.

B. General Requirements:

1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
2. Spring Elements for Spring Isolators:
 - a. Color code or otherwise identify springs to indicate load capacity.
 - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
 - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
 - d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.
 - e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
 - f. Selected to function without undue stress or overloading.

C. Vibration Isolators for Nonseismic Applications:

1. Resilient Material Isolator Pads:
 - a. Description: Single or multiple layer pads utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material.
 - b. Pad Thickness: As required for specified minimum static deflection; minimum 0.25 inch (6 mm) thickness.

- c. Multiple Layer Pads: Provide bonded, galvanized sheet metal separation plate between each layer.
- 2. Resilient Material Isolator Mounts, Nonseismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material; fail-safe type.
- 3. Housed Spring Isolators:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing.
 - b. Furnished with integral elastomeric snubbing elements, nonadjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
 - c. Bottom Load Plate: Steel with nonskid, elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - d. Furnished with integral leveling device for positioning and securing supported equipment.
- 4. Resilient Material Isolator Hangers, Nonseismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material for the lower hanger rod connection.
- 5. Spring Isolator Hangers, Nonseismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) in series with an elastomeric element for the lower hanger rod connection.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Secure fasteners according to manufacturer's recommended torque settings.
- D. Install flexible piping connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- E. Vibration Isolation Systems:

1. Vibration-Isolated Equipment Support Bases:
 - a. Provide specified minimum clearance beneath base.
2. Spring Isolators:
 - a. Position equipment at operating height; provide temporary blocking as required.
 - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
 - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
3. Isolator Hangers:
 - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
 - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
4. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
5. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
6. Adjust isolators to be free of isolation short circuits during normal operation.
7. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

3.3 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect vibration isolation and/or seismic control components for damage and defects.
- C. Vibration Isolation Systems:
 1. Verify isolator static deflections.
 2. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- D. Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Adhesive-backed duct markers.
- D. Stencils.
- E. Pipe markers.
- F. Ceiling tacks.

1.2 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturers catalog literature for each product required.
- C. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Dampers: Ceiling tacks, where located above lay-in ceiling.
- F. Ductwork: Stencilled painting.
- G. Instrumentation: Tags.

- H. Major Control Components: Nameplates.
- I. Piping: Tags.
- J. Small-sized Equipment: Tags.
- K. Thermostats: Nameplates.
- L. Valves: Tags and ceiling tacks where located above lay-in ceiling.

2.2 NAMEPLATES

- A. Letter Color: White.
- B. Letter Height: 1/4 inch (6 mm).
- C. Background Color: Black.

2.3 TAGS

- A. Manufacturers:
 - 1. Seton Identification Products, a Tricor Company; _____: www.seton.com/#sle.
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch (40 mm) diameter.
- C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.

2.4 STENCILS

- A. Manufacturers:
 - 1. Seton Identification Products, a Tricor Company; _____: www.seton.com/#sle.
- B. Stencils: With clean cut symbols and letters of following size:

2.5 PIPE MARKERS

- A. Manufacturers:
 - 1. Seton Identification Products, a Tricor Company; _____: www.seton.com/#sle.
- B. Color: Comply with ASME A13.1.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.

2.6 CEILING TACKS

- A. Manufacturers:
 - 1. Craftmark Pipe Markers; _____: www.craftmarkid.com/#sle.
- B. Description: Steel with 3/4 inch (20 mm) diameter color coded head.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Use tags on piping 3/4 inch (20 mm) diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet (6 m) on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- F. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
- G. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
- B. Commissioning activities.

1.2 RELATED REQUIREMENTS

- A. Section 019113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 230800 - Commissioning of HVAC.

1.3 REFERENCE STANDARDS

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition; 2016.
- B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2024, with Errata (2025).
- C. NEBB (TAB) - Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems; 2019, with Errata (2022).
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2023.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Include at least the following in the plan:
 - a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - c. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - d. Final test report forms to be used.

- e. Procedures for formal deficiency reports, including scope, frequency and distribution.
- D. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
 - 1. Revise TAB plan to reflect actual procedures and submit as part of final report.
 - 2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
 - 3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 - 4. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
 - 5. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 - 1. AABC (NSTSB), AABC National Standards for Total System Balance.
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 - 2. Having minimum of three years documented experience.
 - 3. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
- D. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.

6. Fans are rotating correctly.
 7. Fire and volume dampers are in place and open.
 8. Air coil fins are cleaned and combed.
 9. Access doors are closed and duct end caps are in place.
 10. Air outlets are installed and connected.
 11. Duct system leakage is minimized.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

3.3 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.4 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

- K. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches (12.5 Pa) positive static pressure near the building entries.
- L. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.5 COMMISSIONING

- A. See Sections 019113 - General Commissioning Requirements and 230800 for additional requirements.
- B. Perform prerequisites prior to starting commissioning activities.
- C. Fill out Prefunctional Checklists for:
 - 1. Air side systems.
 - 2. Water side systems.
- D. Furnish to the Commissioning Provider, upon request, any data gathered but not shown in the final TAB report.
- E. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for ____ percent of the air handlers plus a random sample equivalent to ____ percent of the final TAB report data as directed by Commissioning Provider.
 - 1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Provider.
 - 2. Use the same test instruments as used in the original TAB work.
 - 3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
 - 4. For purposes of re-check, failure is defined as follows:
 - a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
 - b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
 - c. Temperatures: Deviation of more than one degree F (0.5 degree C).
 - d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
 - e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
 - 5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.
- F. In the presence of the Commissioning Provider, verify that:
 - 1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.

2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Duct insulation.
- A. Flexible removable and reusable blanket insulation.
- B. Duct liner.
- C. Weather barrier coatings.
- D. Jacketing and accessories.

1.2 RELATED REQUIREMENTS

- A. Section 230553 - Identification for HVAC Piping and Equipment.

1.3 REFERENCE STANDARDS

- A. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.
- C. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2024.
- D. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014 (Reapproved 2019).
- E. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2025.
- F. ASTM D5590 - Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay; 2017 (Reapproved 2021).
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- H. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.
- I. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015, with Editorial Revision (2021).

- J. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- K. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.
- L. UL 181A - Closure Systems for Use with Rigid Air Ducts; Current Edition, Including All Revisions.
- M. UL 181B - Closure Systems for Use with Flexible Air Ducts and Air Connectors; Current Edition, Including All Revisions.
- N. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. K (Ksi) value: 0.36 at 75 degrees F (0.052 at 24 degrees C), when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 250 degrees F (121 degrees C).
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.

2.3 GLASS FIBER, RIGID

A. Manufacturer:

1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
2. Johns Manville; _____: www.jm.com/#sle.
3. Knauf Insulation; Earthwool Insulation Board: www.knaufinsulation.com/#sle.

B. Insulation: ASTM C612; rigid, noncombustible.

1. K (Ksi) Value: 0.24 at 75 degrees F (0.036 at 24 degrees C), when tested in accordance with ASTM C518.
2. Maximum Service Temperature: 450 degrees F (232 degrees C).
3. Maximum Water Vapor Absorption: 5.0 percent.
4. Maximum Density: 8.0 pcf (128 kg/cu m).

2.4 WEATHER BARRIER COATINGS

A. Weather-Resistive Barrier Coating: Fire-resistive, UV resistant, water-based mastic for use over closed cell polyethylene and polyurethane foam insulation; applied with glass fiber or synthetic reinforcing mesh.

1. Surface Burning Characteristics: Flame spread index of 25 or less, smoke developed index of 450 or less, Class A, when tested in accordance with ASTM E84.
2. Water Vapor Permeance: Greater than 1.0 perm (57 ng/(Pa s m)) in accordance with ASTM E96/E96M.
3. Resistance to Fungal Growth: No growth when tested in accordance with ASTM D5590.
4. Color: As selected by Architect.

2.5 JACKETING AND ACCESSORIES

A. Aluminum Jacket:

1. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch (0.41 mm) with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
2. Thickness: 0.016 inch (0.40 mm) sheet.
3. Finish: Smooth.
4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
5. Fittings: 0.016 inch (0.40 mm) thick die-shaped fitting covers with factory-attached protective liner.
6. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.010 inch (0.25 mm) thick stainless steel.

2.6 DUCT LINER

A. Manufacturers:

1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
2. Johns Manville; _____: www.jm.com/#sle.
3. Knauf Insulation; Performance+ Duct Liner: www.knaufinsulation.com/#sle.

B. Note: Choose the liner type - Elastomeric Foam, Glass Fiber, or Phenolic Foam.

- C. Glass Fiber Insulation: Non-corrosive, incombustible glass fiber complying with ASTM C1071; flexible blanket, rigid board, and preformed round liner board; impregnated surface and edges coated with poly vinyl acetate polymer, acrylic polymer, or black composite.
 - 1. Fungal Resistance: No growth when tested according to ASTM G21.
 - 2. Apparent Thermal Conductivity: Maximum of 0.31 at 75 degrees F (0.045 at 24 degrees C).
 - 3. Service Temperature: Up to 250 degrees F (121 degrees C).
 - 4. Rated Velocity on Coated Air Side for Air Erosion: 5,000 fpm (25.4 m/s), minimum.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Test ductwork for design pressure prior to applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exterior Applications: Provide insulation with vapor barrier jacket. Cover with outdoor jacket finished; see Section _____.
- D. Slope exterior ductwork to shed water.
- E. External Duct Insulation Application:
 - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 - 2. Secure insulation without vapor barrier with staples, tape, or wires.
 - 3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
 - 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 - 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Piping insulation.
- B. Flexible removable and reusable blanket insulation.
- C. Weather barrier coatings.
- D. Jacketing and accessories.

1.2 RELATED REQUIREMENTS

- A. Section 232300 - Refrigerant Piping: Placement of inserts.

1.3 REFERENCE STANDARDS

- A. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2025.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- D. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturers:
 - 1. Armacell LLC; AP ArmaFlex: www.armacell.us/#sle.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
 - 1. Minimum Service Temperature: Minus 40 degrees F (Minus 40 degrees C).
 - 2. Maximum Service Temperature: 180 degrees F (82 degrees C).
 - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
- D. Weather Barrier Coating: Air dried, contact adhesive, compatible with insulation and ASTM E84 compliant.

2.3 WEATHER BARRIER COATINGS

2.4 JACKETING AND ACCESSORIES

- A. Aluminum Jacket:
 - 1. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch (0.41 mm) with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
 - 2. Thickness: 0.016 inch (0.40 mm) sheet.
 - 3. Type: Factory-applied, self-adhesive jacketing.
 - 4. Finish: Smooth.
 - 5. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
 - 6. Fittings: 0.016 inch (0.40 mm) thick die-shaped fitting covers with factory-attached protective liner.
 - 7. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

- B. Install in accordance with NAIMA National Insulation Standards.

END OF SECTION 230719

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
- B. Sequence of operation for:
 - 1. Air terminal units.
 - 2. Central refrigeration systems.
 - 3. Excess pressure controls.
 - 4. Fan coil units.
 - 5. Heating coils.
 - 6. Refrigeration systems.

1.2 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
 - 1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
 - 2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in Contract Documents.
 - 3. Include at least the following sequences:
 - a. Start-up.
 - b. Normal operating mode.
 - c. Unoccupied mode.
 - d. Shutdown.
 - e. Capacity control sequences and equipment staging.
 - f. Temperature and pressure control, such as setbacks, setups, resets, etc.
 - g. Sequences for all alarms and emergency shut downs.
 - 4. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
- C. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
- D. Points List: Submit list of all control points indicating at least the following for each point.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 AIR TERMINAL UNITS

- A. Single-duct Variable Volume:
 - 1. Cooling Only:
 - a. On a rise in space temperature, the damper will modulate to provide maximum airflow.
 - b. As space temperature decreases, the damper will modulate down to its minimum airflow.
 - 2. Cooling with Reheat:
 - a. On a rise in space temperature above the cooling set-point, the unit modulates to its maximum airflow.
 - b. As the space temperature falls below the cooling set-point, the unit modulates to its minimum airflow.
 - c. As the space temperature continues to fall to the heating set-point, the terminal modulates to its heating minimum airflow. At this point, the heat will be staged on as follows:

3.2 CENTRAL REFRIGERATION SYSTEMS

3.3 EXCESS PRESSURE CONTROLS

3.4 FAN COIL UNITS

- A. Single temperature unit mounted thermostat set at 75 degrees F (24 degrees C) maintains constant space temperature during the day and 15 degrees F cooler at night (during the day and 8 degrees C cooler at night) by modulating four-way control valve. During heating cycle, modulate hot water supply to coil and divert return modulate chilled water supply to coil and divert return water to cooling return pipe. When space temperature is at thermostat setting, prevent flow from occurring in either circuit and in coil.

3.5 HEATING COILS

- A. Single temperature room thermostat set at 75 degrees F (24 degrees C) maintains constant space temperature by energizing electric heaters.

3.6 REFRIGERATION SYSTEMS

- A. Maintain constant supply air duct temperature of 55 degrees F (13 degrees C) by cycling refrigeration system and signalling step capacity, minimum of _____ steps.

END OF SECTION 230993

SECTION 232300 - REFRIGERANT PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Check valves.
- G. Pressure regulators.
- H. Pressure relief valves.
- I. Filter-driers.
- J. Solenoid valves.
- K. Expansion valves.
- L. Receivers.
- M. Conduit for piping.
- N. Flexible connections.

1.2 RELATED REQUIREMENTS

- A. Section 230716 - HVAC Equipment Insulation.

1.3 REFERENCE STANDARDS

- A. AHRI 710 (I-P) - Performance Rating of Liquid-Line Driers; 2009.
- B. AHRI 711 (SI) - Performance Rating of Liquid-Line Driers; 2009.
- C. AHRI 760 (I-P) - Performance Rating of Solenoid Valves for Use with Volatile Refrigerants; 2014.
- D. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2024, with Addendum (2025).

- E. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants; 2024, with Addendum (2025).
- F. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- G. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2022.
- H. ASME B31.9 - Building Services Piping; 2025.
- I. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2023.
- J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- K. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.
- L. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.
- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.
- B. Liquid Indicators:
 - 1. Use line size liquid indicators in main liquid line leaving condenser.
 - 2. If receiver is provided, install in liquid line leaving receiver.
 - 3. Use line size on leaving side of liquid solenoid valves.

C. Valves:

1. Use service valves on suction and discharge of compressors.
2. Use gauge taps at compressor inlet and outlet.
3. Use gauge taps at hot gas bypass regulators, inlet and outlet.
4. Use check valves on compressor discharge.
5. Use check valves on condenser liquid lines on multiple condenser systems.

D. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.

E. Strainers:

1. Use line size strainer upstream of each automatic valve.
2. Where multiple expansion valves with integral strainers are used, use single main liquid line strainer.

F. Pressure Relief Valves: Use on ASME receivers and pipe to outdoors.

G. Filter-Driers:

1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.

H. Solenoid Valves:

1. Use in liquid line of systems operating with single pump-out or pump-down compressor control.
2. Use in liquid line of single or multiple evaporator systems.
3. Use in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

I. Receivers:

1. Use on systems with long piping runs.

J. Flexible Connectors: Utilize at or near compressors where piping configuration does not absorb vibration.

2.2 REGULATORY REQUIREMENTS

- A. Comply with ASME B31.9 for installation of piping system.
- B. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

2.3 PIPING

A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.

1. Fittings: ASME B16.22 wrought copper.
2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

B. Preinsulated Refrigerant Piping Linesets:

1. Copper Tube: ASTM B280 seamless, anticorrosion pipe; lineset is precoupled to include two joined pipes.
2. Insulation: Polyethylene closed-cell foam; preapplied to entire length of lineset. Weather- and UV-resistant for outdoor installation. Maximum flame spread index of 25 and maximum smoke developed index of 50, when tested in accordance with ASTM E84 or UL 723.

C. Pipe Supports and Anchors:

1. Provide hangers and supports complying with MSS SP-58.
 - a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
2. Hangers for Pipe Sizes 2 Inches (50 mm) and Over: Carbon steel, adjustable, clevis.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
4. Wall Support for Pipe Sizes to 3 Inches (75 mm): Cast iron hook.
5. Vertical Support: Steel riser clamp.
6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
7. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
8. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 REFRIGERANT

- A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) no greater than that allowed by federal code.
- B. Refrigerant: R-454B as defined in ASHRAE Std 34.

2.5 MOISTURE AND LIQUID INDICATORS

- A. Indicators: Single port type, UL listed, with copper or brass body, flared or soldered ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F (93 degrees C) and maximum working pressure of 500 psi (3450 kPa).

2.6 VALVES

- A. Diaphragm Packless Valves:
 1. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, soldered or flared ends, with positive backseating; for maximum working pressure of 500 psi (3450 kPa) and maximum temperature of 275 degrees F (135 degrees C).
- B. Packed Angle Valves:
 1. Forged brass or nickel plated forged steel, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, soldered or flared ends; for

maximum working pressure of 500 psi (3450 kPa) and maximum temperature of 275 degrees F (135 degrees C).

2.7 STRAINERS

- A. Straight Line or Angle Line Type:
 - 1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi (2960 kPa).

2.8 PRESSURE REGULATORS

- A. Brass body, stainless steel diaphragm, direct acting, adjustable over 0 to 80 psi (0 to 550 kPa) range, for maximum working pressure of 450 psi (3100 kPa).

2.9 PRESSURE RELIEF VALVES

- A. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB, selected to ASHRAE Std 15, with standard setting of 235 psi (1620 kPa).

2.10 FILTER-DRIERS

- A. Performance:
 - 1. Flow Capacity - Liquid Line: ____ ton (____ kW), minimum, rated in accordance with AHRI 710 (I-P) (AHRI 711 (SI)).
 - 2. Pressure Drop: 2 psi (14 kPa), maximum, when operating at full connected evaporator capacity.
 - 3. Design Working Pressure: 350 psi (2410 kPa), minimum.
- B. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns, with secondary filtration to 20 microns; of construction that will not pass into refrigerant lines.
- C. Construction: UL listed.
 - 1. Connections: As specified for applicable pipe type.

2.11 SOLENOID VALVES

- A. Valve: AHRI 760 (I-P), pilot operated, copper, brass or steel body and internal parts, synthetic seat, stainless steel stem and plunger assembly (permitting manual operation in case of coil failure), integral strainer, with flared, soldered, or threaded ends; for maximum working pressure of 500 psi (3450 kPa).

2.12 EXPANSION VALVES

- A. Angle or Straight Through Type: AHRI 760 (I-P); design suitable for refrigerant, brass body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with nonreplaceable capillary tube and remote sensing bulb and remote bulb well.
- B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F (6 degrees C) superheat. Select to avoid being undersized at full load and excessively oversized at part load.

2.13 ELECTRONIC EXPANSION VALVES

- A. Valve:
- B. Refrigeration System Control: Electronic microprocessor based unit in enclosed case, with proportional integral control of valve, on/off thermostat, air temperature alarm (high and low), solenoid valve control, liquid injection adaptive superheat control, maximum operating pressure function, night setback thermostat, timer for defrost control.

2.14 RECEIVERS

- A. Internal Diameter 6 inch (150 mm) and Smaller:

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- E. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.5.
 - 2. Support horizontal piping as indicated.
 - 3. Install hangers to provide minimum 1/2 inch (13 mm) space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches (300 mm) of each horizontal elbow.
 - 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 7. Provide copper plated hangers and supports for copper piping.

- F. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- G. Provide clearance for installation of insulation and access to valves and fittings.
- H. Flood piping system with nitrogen when brazing.
- I. Insulate piping and equipment.
- J. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- K. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
- L. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- M. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- N. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
- O. Fully charge completed system with refrigerant after testing.

3.2 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Test refrigeration system in accordance with ASME B31.5.
- C. Pressure test system with dry nitrogen to 200 psi (1380 kPa). Perform final tests at 27 inches (92 kPa) vacuum and 200 psi (1380 kPa) using halide torch. Test to no leakage.

END OF SECTION 232300

SECTION 233100 - HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Metal ducts.
- B. Flexible ducts.

1.2 RELATED REQUIREMENTS

- A. Section 230548 - Vibration and Seismic Controls for HVAC.
- B. Section 230713 - Duct Insulation: External insulation and duct liner.
- C. Section 233300 - Air Duct Accessories.
- D. Section 233319 - Duct Silencers.
- E. Section 233600 - Air Terminal Units.
- F. Section 233700 - Air Outlets and Inlets: Fabric air distribution devices.

1.3 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; Most Recent Edition Cited by Referring Code or Reference Standard.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2025a.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- E. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.
- F. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- G. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.

- B. Product Data: Provide data for duct materials.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Provide UL Class 1 ductwork, fittings, hangers, supports, and appurtenances in accordance with NFPA 90A and SMACNA (DCS) guidelines unless stated otherwise.
- B. Provide metal duct unless otherwise indicated. Fibrous glass duct can be substituted at the Contractor's option.
- C. Acoustical Treatment: Provide sound-absorbing liners and sectional silencers for metal-based ducts in compliance with Section 233319.
- D. Duct Shape and Material in accordance with Allowed Static Pressure Range:
- E. Duct Sealing and Leakage in accordance with Static Pressure Class:
- F. Duct Fabrication Requirements:
 - 1. Duct and Fitting Fabrication and Support: SMACNA (DCS) including specifics for continuously welded round and oval duct fittings.
 - 2. Use reinforced and sealed sheet-metal materials at recommended gauges for indicated operating pressures or pressure class.
 - 3. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide airfoil turning vanes of perforated metal with glass fiber insulation.
 - 4. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.
 - 5. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
 - 6. Provide turning vanes of perforated metal with glass fiber insulation when an acoustical lining is required.
 - 7. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.2 METAL DUCTS

- A. Material Requirements:
 - 1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.
- B. Metal Duct Coating Requirements:
 - 1. Antimicrobial Coating: Factory- or field-applied in accordance with manufacturer's instructions.
- C. Rectangular Metal Duct:

1. Rectangular Single Wall: Rectangular, longitudinal lock seam duct with galvanized steel wall.
2. Rectangular Double Wall Insulated: Rectangular, longitudinal lock seam duct with galvanized steel outer wall, perforated galvanized steel inner wall; fitting with solid inner wall.
 - a. Insulation:
 - 1) Thickness: 1 inch (25 mm).
 - 2) Material: Air.

D. Round Metal Ducts:

1. Round Double Wall Insulated Duct: Round spiral lock seam duct with galvanized steel outer wall, perforated galvanized steel inner wall; fitting with the solid inner wall.
 - a. Insulation:
 - 1) Thickness: 1 inch (25 mm).
 - 2) Material: Air.
2. Round Connection System: Interlocking duct connection system in accordance with SMACNA (DCS).

E. Round Spiral Duct:

1. Round spiral lock seam duct with galvanized steel outer wall.

F. Connectors, Fittings, Sealants, and Miscellaneous:

1. Fittings: Manufacture with solid inner wall of perforated galvanized steel.
2. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - a. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - b. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.

2.3 FLEXIBLE DUCTS

A. Flexible Air Ducts:

1. UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound spring steel wire.
2. Insulation: Fiberglass insulation with polyethylene vapor barrier film.
3. Pressure Rating: From 10 in-wc (2.5 kPa) positive to 1 in-wc (250 Pa) negative.
4. Maximum Velocity: 4,000 fpm (20.3 m/s).
5. Temperature Range: Minus 20 to 210 degrees F (Minus 28 to 99 degrees C).

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install products following the manufacturer's instructions.

- C. Comply with safety standards NFPA 90A and NFPA 90B.
- D. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering the ductwork system.
- E. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- F. Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.
- G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- H. Connect terminal units to supply ducts directly or with one foot (300 mm) maximum length of flexible duct. Do not use flexible duct to change direction.
- I. At exterior wall louvers, seal duct to louver frame and install blank-out panels.
- J. Duct Insulation: Provide duct insulation. See Section 230713.

END OF SECTION 233100

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Backdraft dampers - metal.
- C. Backdraft dampers - fabric.
- D. Barometric pressure relief dampers.
- E. Combination fire and smoke dampers.
- F. Duct access doors.
- G. Duct test holes.
- H. Fire dampers.
- I. Flexible duct connectors.
- J. Smoke dampers.
- K. Volume control dampers.
- L. Air measuring control dampers.

1.2 REFERENCE STANDARDS

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- B. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- C. NFPA 92 - Standard for Smoke Control Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- E. UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

- H. UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.
- I. UL 555C - Standard for Safety Ceiling Dampers; Current Edition, Including All Revisions.
- J. UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide for shop-fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used. Include electrical characteristics and connection requirements.

1.4 QUALITY ASSURANCE

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.1 AIR TURNING DEVICES/EXTRACTORS

- A. Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

2.2 BACKDRAFT DAMPERS - METAL

- A. Manufacturers:
- B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch (150 mm) width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.3 BACKDRAFT DAMPERS - FABRIC

- A. Fabric Backdraft Dampers: Factory-fabricated.
 - 1. Blades: Neoprene coated fabric material.
 - 2. Birdscreen: 1/2 inch (12 mm) nominal mesh of galvanized steel or aluminum.
 - 3. Maximum Velocity: 1000 fpm (5 mps) face velocity.

2.4 BAROMETRIC PRESSURE RELIEF DAMPER

- A. Damper provides pressure relief at differential pressure set points. Blades begin to open in parallel action when start-to-open pressure relief point is reached. Damper continues to open as pressure differential increases. Blades fully open once full-open pressure differential is reached.
- B. Mounting Orientation: As indicated on drawings.
- C. Frame Construction: Use galvanized steel, extruded aluminum, or stainless steel.
 - 1. Size: As indicated on drawings.
- D. Blade Construction: Use aluminum, galvanized steel, or stainless steel.
 - 1. Thickness Minimum: 0.025 inch (0.635 mm).
 - 2. Axles: Use galvanized steel or stainless steel.
- E. Pressure Opening Mechanism: Use counterbalance weight or spring-set. Adjustable in field.
- F. Pressure Drop Maximum: 0.02 in-wc (5 Pa).
 - 1. Measured at 500 fpm (2.5 m/sec).

2.5 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers:
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper.
- D. Multiple Blade Dampers: Fabricate with 16 gauge, 0.0598 inch (1.52 mm) galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch (3.2 by 12.7 mm) plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch (12.7 mm) actuator shaft.
- E. Operators: UL listed and labeled; spring-return, electric-type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on interior of duct and link to damper operating shaft.
- F. Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices to ensure positive closure for units mounted horizontally.
- G. Electro Thermal Link: Fusible link melting at 165 degrees F (74 degrees C); 120 volts, single phase, 60 Hz; UL listed and labeled.

2.6 DUCT ACCESS DOORS

- A. Manufacturers:

1. Acudor Products Inc, a Division of Nelson Industrial Inc; _____: www.acudor.com/#sle.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ducts, install minimum 1-inch (25 mm) thick insulation with sheet metal cover.
- D. Access doors with sheet metal screw fasteners are not acceptable.

2.7 DUCT TEST HOLES

- A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.8 FIRE DAMPERS

- A. Manufacturers:
 1. Nailor Industries, Inc; _____: www.nailor.com/#sle.
- B. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- C. Ceiling (Radiation) Dampers: Galvanized steel, 22-gauge, 0.0299-inch (0.76 mm) frame and 16-gauge, 0.0598-inch (1.52 mm) flap, two layers of 0.125-inch (3.2 mm) thick ceramic fiber on top side and one layer on bottom side for round flaps, with locking clip.
 1. Box Fitting: Factory-provided 26 gauge, 0.0179 inch (0.45 mm) with field-provided collar.
 2. Rated for three hour service in compliance with UL 555C.
- D. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for 1-inch (250 Pa) pressure-class ducts up to 12 inches (300 mm) in height.
- E. Multiple Blade Dampers: 16-gauge, 0.0598-inch (1.52 mm) galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 by 1/2 inch (3.2 by 12.7 mm) plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- F. Fusible Links: UL 33, separate at 160 degrees F (71 degrees C) with adjustable link straps for combination fire/balancing dampers.

2.9 FLEXIBLE DUCT CONNECTORS

- A. Manufacturers:
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Flexible Duct Connections: Fabric crimped into metal edging strip.
 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz/sq yd (1.0 kg/sq m).

- a. Net Fabric Width: Approximately 2 inches (50 mm) wide.

- D. Maximum Installed Length: 14 inch (356 mm).

2.10 SMOKE DAMPERS

- A. Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.
- B. Dampers: UL Class 1 airfoil blade type smoke damper, normally open automatically operated by pneumatic actuator.
- C. Electro Thermal Link: Fusible link melting at 165 degrees F (74 degrees C); 120 volts, single phase, 60 Hz; UL listed and labeled.

2.11 VOLUME CONTROL DAMPERS

- A. Manufacturers:
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Splitter Dampers:
 - 1. Material: Same gauge as duct to 24 inches (600 mm) size in either direction, and two gauges heavier for sizes over 24 inches (600 mm).
 - 2. Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - 3. Operator: Minimum 1/4 inch (6 mm) diameter rod in self aligning, universal joint action, flanged bushing with set screw.
- D. Single Blade Dampers:
 - 1. Fabricate for duct sizes up to 6 by 30 inch (150 by 760 mm).
 - 2. Blade: 24 gauge, 0.0239 inch (0.61 mm), minimum.
- E. Multi-Blade Damper: Fabricate consisting of opposed blades with maximum blade sizes 8 by 72 inches (200 by 1825 mm). Assemble center- and edge-crimped blades in prime-coated or galvanized-channel frame with suitable hardware.
 - 1. Blade: 18 gauge, 0.0478 inch (1.21 mm), minimum.
- F. End Bearings: Except in round ducts 12 inches (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.
- G. Quadrants:
 - 1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.12 AIR MEASURING CONTROL DAMPERS

- A. Factory-Mounted Assembly Requirements:
 - 1. Damper Unit or Multi-Unit:
 - a. Construction: Flanged-to-duct frame made of extruded aluminum with V or 3V blades for low to medium pressure applications, zinc-plated steel hardware, frame-mounted shaft bearings, frame-assembly sleeve, and silicone seals at frame and blade ends.
 - b. Control: Opposed blade modulation by damper actuator(s) from air measuring sensor transmitter-controller unit.
 - 2. Air Measuring Sensor Transmitter-Controller:
 - a. Type: Externally-powered, multi-point, multi-probe airflow and temperature monitoring using sensor array of thermal dispersion type wired to externally-mounted transmitter-controller.
 - b. Air Velocity Monitoring Range: 0 to 2000 fpm (0 to 10.1 m/s), bidirectional. Factory configure monitor calculate airflow and differential pressure from listed range.
 - c. Temperature Monitoring Range: 32 to 104 degrees F (0 to 40 degrees C).
 - d. Differential Pressure Monitoring Range: 0 to 0.05 in-wc (0 to 12.4 Pa), bidirectional.
 - e. Transmitter: Five percent accuracy, adjustable zero and span, 10 to 1 turndown, 0.1 percent of calibrated span linearity, 30 to 50 millisecond response time, minimum overpressure of 150 percent over highest range value, alphanumeric indicating display, wired or wireless connectivity for configuration, and terminal strip within enclosed electronic components.
 - f. Controller: Configure to control hardware-linked damper actuator(s) based on locally typed or software-defined setpoint. Access for user to do local or remote proportional, integrative, and derivative control-loop tuning.
 - g. Hardwired External Damper Actuator Output: Two-wire, 4 to 20 mA.
 - h. BTU Metering: Provide temperature sensor for field mounting upstream or downstream of heating or cooling source.
- B. Service Temperature Range: Minus 20 to 160 degrees F (Minus 28.8 to 71.1 degrees C).
- C. Enclosure Rating for Transmitter-Controller and Damper Actuator(s):
 - 1. General: UL 50 or UL 50E listed for use in non-hazardous locations.

PART 3 EXECUTION

3.1 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). See Section 233100 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

- C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8 by 8 inch (200 by 200 mm) size access door for hand and shoulder access, or as indicated on drawings. Provide minimum 4 by 4 inch (100 by 100 mm) size access door for balancing dampers only. Review locations prior to fabrication.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire-rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- F. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- G. Demonstrate re-setting of fire dampers to Owner's representative.
- H. Use splitter dampers only where indicated.

END OF SECTION 233300

SECTION 233319 - DUCT SILENCERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Air transfer silencers.
- B. Cross-talk silencers.

1.2 RELATED REQUIREMENTS

- A. Section 233300 - Air Duct Accessories: Flexible duct connections.

1.3 REFERENCE STANDARDS

- A. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; Most Recent Edition Cited by Referring Code or Reference Standard.
- B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- D. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance.

PART 2 PRODUCTS

2.1 AIR TRANSFER SILENCERS

- A. Description: Duct sections with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction. Fabricate in accordance with SMACNA (DCS) HVAC Duct Construction Standards.
- B. Configuration: Rectangular, lined with inner casing with splitters with radiused noses and contoured tails, ____ high, ____ wide, ____ long.
- C. Materials:

1. Outer Casing: Minimum 22 gauge, 0.0299 inch (0.76 mm) thick galvanized steel with mastic filled lock formed seams, 3 inch (75 mm) long, 11 gauge, 0.1196 inch (3.04 mm) slip joint on both ends.
2. Inner Casing and Splitters: Minimum 24 gauge, 0.0239 inch (0.61 mm) thick perforated galvanized steel.
3. Fill: Glass fiber or mineral wool of minimum 4 lb/cu ft (64 kg/cu m) density.
4. Fill Liner: Bonded glass fiber matting.

2.2 CROSS-TALK SILENCERS

- A. Manufacturers:
 1. Price Industries, Inc; _____: www.priceindustries.com/#sle.
- B. Description: Duct sections with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction. Fabricate in accordance with SMACNA (DCS) HVAC Duct Construction Standards.
- C. Configuration: Rectangular, lined with inner casing with splitters with radiused noses and contoured tails, _____ high, _____ wide, _____ long.
- D. Materials:
 1. Inner Casing and Splitters: Minimum 24 gauge, 0.0239 inch (0.61 mm) thick perforated galvanized steel.
 2. Fill: Glass fiber or mineral wool of minimum 4 lb/cu ft (64 kg/cu m) density.
 3. Fill Liner: Bonded glass fiber matting.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Support duct silencers independent of ducts with flexible duct connections, lagged with leaded vinyl sheet on inlet and outlet. See Section 233100 and Section 233300.
- C. Install cross-talk silencers above ceiling.

END OF SECTION 233319

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Forward curved centrifugal fans.
- B. Bearings and drives.

1.2 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015 (Reaffirmed 2020).
- B. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- C. AMCA 99 - Standards Handbook; 2016.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2016, with Errata (2018).
- E. AMCA 300 - Reverberation Room Methods of Sound Testing of Fans; 2024.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2022.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Manufacturer's Instructions: Include complete installation instructions.

1.4 QUALITY ASSURANCE

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Geeenheck.

2.2 PERFORMANCE REQUIREMENTS

- A. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
- C. Fabrication: Comply with AMCA 99.
- D. Performance Base: Sea level conditions.

2.3 WHEEL AND INLET

- A. Forward Curved: Black enameled steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; steel hub swaged to backplate and keyed to shaft with set screw.

2.4 HOUSING

2.5 BEARINGS AND DRIVES

- A. Bearings: Heavy duty pillow block type, selfgreasing ball bearings, with ABMA STD 9 life at 50,000 hours.
- B. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil, and shaft guard.
- C. Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 hp (11.2 Kw) and under, selected so required rpm is obtained with sheaves set at mid Fixed sheave for 20 hp (15 Kw) and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install flexible connections between fan inlet and discharge ductwork; see Section 233300. Ensure metal bands of connectors are parallel with minimum one inch (25 mm) flex between ductwork and fan while running.
- C. Provide backdraft dampers on exhaust fans located at discharge side; see Section 233300.

END OF SECTION 233416

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Roof exhausters.
- B. Roof ventilators.
- C. Cabinet exhaust fans.
- D. Ceiling exhaust fans.
- E. Inline centrifugal fans and blowers.

1.2 RELATED REQUIREMENTS

- A. Section 230548 - Vibration and Seismic Controls for HVAC.
- B. Section 233300 - Air Duct Accessories: Backdraft dampers.

1.3 REFERENCE STANDARDS

- A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- B. AMCA 99 - Standards Handbook; 2016.
- C. AMCA 204 - Balance Quality and Vibration Levels for Fans; 2020.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2016, with Errata (2018).
- E. AMCA 300 - Reverberation Room Methods of Sound Testing of Fans; 2024.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2022.
- G. UL 705 - Power Ventilators; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on fans and accessories, including fan curves with specified operating point plotted, power, rpm, sound power levels at rated capacity, and electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.

2.2 POWER VENTILATORS - GENERAL

- A. Static and Dynamically Balanced: Comply with AMCA 204.
- B. Performance Ratings: Comply with AMCA 210, bearing certified rating seal.
- C. Sound Ratings: Comply with AMCA 301, tested to AMCA 300, bearing certified sound ratings seal.
- D. Fabrication: Comply with AMCA 99.
- E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.3 ROOF EXHAUSTERS

- A. Manufacturers:
 - 1. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
- B. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch (13 mm) mesh, 0.62 inch (1.6 mm) thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- C. Roof Curb: 8 inch (200 mm) high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.
- D. Disconnect Switch: Factory wired, nonfusible, in housing for thermal overload protected motor and wall mounted multiple speed switch.
- E. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- F. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm gets attained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.4 CABINET EXHAUST FANS

- A. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resiliently mounted motor, gravity backdraft damper in discharge.
- B. Disconnect Switch: Cord and plug-in housing for thermal overload protected motor and wall mounted switch.

- C. Grille: Molded white plastic.
- D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is reached with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.5 INLINE CENTRIFUGAL FANS AND BLOWERS

- A. Manufacturers:
 - 1. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
- B. Centrifugal Fan Unit: V-belt or direct driven, with galvanized steel housing lined with acoustic insulation, resiliently-mounted motor, gravity backdraft damper in discharge.
- C. Forward Curved Blower:
 - 1. Direct-driven, resiliently mounted motor, heavy-duty ball bearings, galvanized steel housing for indoor or outdoor service, and removable service panels.
 - 2. Accessories: Provide filter section, intake hood with bird screen, and MERV- __ filters.
- D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm gets reached with sheaves set at mid-position; fan shaft with self-aligning prelubricated ball bearings.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- D. Hung Cabinet Fans:
 - 1. Install fans with resilient mountings and flexible electrical leads, see Section 230548.
 - 2. Install flexible connections between fan and ductwork; see Section 233300. Ensure metal bands of connectors are parallel with minimum 1 inch (25 mm) flex between ductwork and fan while running.
- E. Provide sheaves required for final air balance.
- F. Install backdraft dampers on inlet to roof and wall exhausters.
- G. Provide backdraft dampers on outlet from cabinet and ceiling exhauster fans and as indicated.

END OF SECTION 233423

SECTION 233600 - AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Single-duct terminal units.
 - 1. Constant-volume units.
 - 2. Variable-volume units.
- B. Controls for terminal units.

1.2 RELATED REQUIREMENTS

- A. Section 230548 - Vibration and Seismic Controls for HVAC.
- B. Section 230993 - Sequence of Operations for HVAC Controls.
- C. Section 233100 - HVAC Ducts and Casings.
- D. Section 233300 - Air Duct Accessories.
- E. Section 233700 - Air Outlets and Inlets.
- F. Section 251400 - Integrated Automation Local Control Units: HVAC controllers.
- G. Section 251500 - Integrated Automation Software: BAS or BMS.
- H. Section 253513 - Integrated Automation Actuators and Operators: Actuators.
- I. Section 253516 - Integrated Automation Sensors and Transmitters: Sensors and switches.

1.3 REFERENCE STANDARDS

- A. AHRI 880 (I-P) - Performance Rating of Air Terminals; 2017 (Reaffirmed 2023).
- B. ASHRAE RP-1455 - Seminar 65 - Standardized Best of Class Sequences for HVAC Systems; 2016.
- C. ASTM A492 - Standard Specification for Stainless Steel Rope Wire; 1995 (Reapproved 2019).
- D. ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope; 2019.
- E. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2025.
- F. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.

- G. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- J. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; 2024.
- K. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate airflow, static pressure, and NC designation. Include electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.1 SINGLE-DUCT, VARIABLE-VOLUME AND CONSTANT-VOLUME UNITS

- A. Manufacturers:
 - 1. Trane Technologies, PLC; _____: www.trane.com/#sle.
- B. General:
 - 1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with damper assembly, flow sensor, externally mounted volume controller, duct collars, and all required features.
 - 2. Control box bearing identification, including but not necessarily limited to nominal cfm, maximum and minimum factory-set airflow limits, coil type and coil (right or left hand) connection, where applicable.
- C. Unit Casing:
 - 1. Minimum 22 gauge, 0.0299 inch (0.76 mm) galvanized steel.
 - 2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes.
 - 3. Unit Discharge: Rectangular, with slip-and-drive connections.
 - 4. Acceptable Liners:
 - a. 1/2 inch (13 mm) thick, coated, fibrous-glass complying with ASTM C1071.
 - 1) Secure with adhesive.
 - 2) Coat edges exposed to airstream with NFPA 90A approved sealant.
 - 3) Cover liner with non-porous foil.
 - b. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.
- D. Damper Assembly:

1. Heavy-gauge, galvanized steel, or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
2. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.
3. Incorporate low leak damper blades for tight airflow shutoff.

E. Electric Heating Coil:

1. Listed and provided by the terminal unit manufacturer.
2. Coil Casing: 20 gauge, 0.0359 inch (0.92 mm) galvanized steel.
3. Heating Elements: Nickel chrome, supported by ceramic insulators.
4. Integral Control Panel: NEMA EN 10250, Type 2 enclosure with hinged access door for access to all controls and safety devices.
5. Furnish a primary automatic reset thermal cutout and differential pressure airflow switch for proof of airflow.
6. Provide the following additional components, mounted and/or wired within the control enclosure:
 - a. Fused or non-fused door interlocking disconnect switch.
 - b. Mercury contactors.
 - c. Fuse block.
7. Factory wired, including all limit switches and steps of control as indicated on the equipment schedule, with the SSR (solid-state relay) proportional heat control.

F. Electrical Requirements:

1. Single-point power connection.
2. Equipment wiring to comply with requirements of NFPA 70.

G. Control Transformers: Factory supplied and mounted for electric and electronic control applications.

H. Controls:

1. DDC (Direct-Digital Controls):
 - a. Include a factory-installed, unit-mounted, direct-digital controller.
 - b. Bi-directional Damper Actuator: 24 volt, powered closed, spring return open.
 - c. Microprocessor-Based Controller: Air volume controller, pressure-independent with electronic airflow transducers, factory-calibrated maximum and minimum CFMs.
 - 1) Occupied and unoccupied operating mode.
 - 2) Remote reset of temperature or CFM set points.
 - 3) Proportional, plus integral control of room temperature.
 - 4) Monitoring and adjusting with portable terminal.
 - d. Room Sensor:
 - 1) Compatible with temperature controls specified.
 - 2) Wall-mounted, system powered, with temperature set-point adjustment including connection access for portable operator terminal.
 - e. See Section 25 1400.
2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.
 - a. Signal accuracy: Plus/minus five percent throughout terminal operating range.

2.2 CONTROLS FOR TERMINAL UNITS

- A. Direct or Distributed Digital Controller (DDC), Integrated:
 - 1. Provide application specific controller, see Section 251400 and 251500.
 - 2. Accuracy: Plus/minus five percent of analog input readings and analog outputs.
 - 3. Sequence of Operation: Follow ASHRAE RP-1455 for specific terminal unit.
 - 4. Zone Thermostat:
 - a. Temperature sensor based device, see Section 253516.
 - b. Wall-mounted with occupancy sensor, setpoint adjust, and service port.
 - 5. Damper Actuator:
 - a. Direct-mounted, modulating, fail last actuator, see Section 253513.
 - 6. Heater Section:
 - a. SCR (silicone-controlled rectifier) unless factory-provided.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- C. Provide ceiling access doors or locate units above easily removable ceiling components.
- D. Support units individually from structure with wire rope complying with ASTM A492 and ASTM A603 in accordance with SMACNA (SRM). See Section 23 0548.
- E. Do not support from ductwork.
- F. Connect to ductwork in accordance with Section 233100.
- G. Provide minimum of 5 ft (1.5 m) of 1 inch (25 mm) thick lined ductwork downstream of units.
- H. Verify that electric power is available and of the correct characteristics.

3.2 CLEANING

- A. Vacuum clean coils and inside of units.
- B. Install new filters.

END OF SECTION 233600

SECTION 233700 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Diffusers:
- B. Rectangular ceiling diffusers.
- C. Slot ceiling diffusers.
- D. VAV (variable air volume) diffusers.
- E. Registers/grilles:
 - 1. Ceiling-mounted, egg crate exhaust and return register/grilles.
 - 2. Ceiling-mounted, exhaust and return register/grilles.
 - 3. Ceiling-mounted, linear exhaust and return register/grilles.
 - 4. Ceiling-mounted, supply register/grilles.
 - 5. Wall-mounted, supply register/grilles.
 - 6. Wall-mounted, exhaust and return register/grilles.
- F. Fabric air distribution devices.
- G. Gravity ventilators.

1.2 REFERENCE STANDARDS

- A. AMCA 511 - Certified Ratings Program Product Rating Manual for Air Control Devices; 2021, with Editorial Revision (2022).
- B. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers; 2022.
- C. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets; 2023.
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.
- G. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- H. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.
- I. UL 2518 - Standard for Safety Air Dispersion Systems; Current Edition, Including All Revisions.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Price Industries; _____: www.priceindustries.com/#sle.

2.2 RECTANGULAR CEILING DIFFUSERS

- A. Type: Provide rectangular and square formed adjustable, backpan stamped, core removable, and multi-louvered ceiling diffusers constructed to maintain 360 degree discharge air pattern with sectorizing baffles where indicated.
- B. Connections: Round.
- C. Frame: Provide surface mount, snap-in, inverted T-bar, and spline type. In plaster ceilings, provide plaster frame and ceiling frame.
- D. Color: As selected by Architect from manufacturer's standard range.
- E. Accessories: Provide radial opposed blade, butterfly, and combination splitter volume control damper; removable core, sectorizing baffle, safety chain, wire guard, equalizing grid, operating rod extension, anti-smudging device, and gaskets for surface mounted diffusers with damper adjustable from diffuser face.

2.3 CEILING SLOT DIFFUSERS

- A. Manufacturers:
 - 1. Price Industries.
- B. Fabrication: Aluminum extrusions with factory clear lacquer finish.
- C. Color: To be selected by Architect from manufacturer's standard range.
- D. Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting and gasket, mitered end border.

2.4 CEILING SUPPLY REGISTERS/GRILLES

- A. Manufacturers:
 - 1. Price Industries.

- B. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, one-way deflection.
- C. Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting and gasket.
- D. Construction: Made of aluminum extrusions with factory enamel finish.
- E. Color: As indicated.
- F. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.5 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Manufacturers:
 - 1. _____ Price Industries
- B. Type: Streamlined blades, 3/4 inch (19 mm) minimum depth, 3/4 inch (19 mm) maximum spacing, with blades set at 45 degrees, vertical face.
- C. Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting.
- D. Fabrication: Steel with 20 gauge, 0.0359 inch (0.91 mm) minimum frames and 22 gauge, 0.0299 inch (0.76 mm) minimum blades, steel and aluminum with 20 gauge, 0.0359 inch (0.91 mm) minimum frame, or aluminum extrusions, with factory baked enamel finish.
- E. Color: As indicated.
- F. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

2.6 CEILING LINEAR EXHAUST AND RETURN GRILLES

- A. Manufacturers:
 - 1. Price Industries.
- B. Type: Streamlined blades with 90 degree one-way deflection, 1/8 by 3/4 inch (3.2 by 19 mm) on 1/4 inch (6 mm) centers.
- C. Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting.
- D. Fabrication: Steel with 20 gauge, 0.0359 inch (0.91 mm) minimum frames and 22 gauge, 0.0299 inch (0.76 mm) minimum blades, steel and aluminum with 20 gauge, 0.0359 inch (0.91 mm) minimum frame, or aluminum extrusions, with factory baked enamel finish.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.7 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

- A. Manufacturers:
 - 1. Price Industries.
- B. Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch (13 by 13 by 13 mm) grid core.
- C. Fabrication: Grid core consists of aluminum with mill aluminum finish.
- D. Color: To be selected by Architect from manufacturer's standard range.
- E. Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting.
- F. Frame: Channel lay-in frame for suspended grid ceilings.
- G. Accessories: Provide integral gang and face operated opposed blade damper, 2 inch filter frame (50 mm), plaster frame, square mesh insect screen, square mesh debris screen, prescored molded fiberglass back, and 45 degree angled eggcrate or other similar provisions for visual blocking such as angled louver or 90 degree duct elbow.

2.8 FABRIC AIR DISTRIBUTION DEVICES

- A. General Requirements:
 - 1. Diffuser material to comply with ASTM E84, UL 723, UL 2518, NFPA 90A, and NFPA 90B.
 - 2. Air Dispersion Method:
 - 3. Hanger Supports:

2.9 GRAVITY VENTILATORS

- A. Hood Intake and Relief Gravity Ventilator:
 - 1. Manufacturers:
 - a. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
 - 2. General:
 - a. Low silhouette for intake applications with natural gravity or negative pressure system(s).
 - b. Performance ratings and factory testing in accordance with AMCA 511 and AMCA 550.
 - c. Suitable for non-ducted applications.
 - d. Equipment to bear permanently affixed manufacturer's nameplate listing model and serial number.
 - 3. Hood and Base:
 - a. Material: Aluminum.
 - b. Hood Construction: Precision formed, arched panels with interlocking seams.
 - c. Curb Cap: Pre-punched mounting holes for installation.
 - 4. Birdscreen:
 - a. Construction: 1/2 inch (12.7 mm) Galvanized mesh.
 - b. Horizontally mounted across hood intake area.
 - 5. Hood Support: Galvanized steel construction and fastened so hood can be removed completely from base or hinged open.

6. Options/Accessories:
 - a. Roof Curbs:
 - 1) Flat Roofs:
 - a) Welded, straight side curb with flashing flange and wood nailer.
 - b) Tabbed and riveted curb with 45 degree cant and wood nailer.
 - c) Welded curb with 45 degree cant and wood nailer.
 - 2) Mounted on roof with fan.
 - 3) Material: Aluminum.
 - 4) Insulation Thickness: 1 inch (25.4 mm).
 - b. Provide extended base minimum 7 inch (177.8 mm) extension to base height making overall base 12 inches (304.8 mm) in height to prevent snow or moisture intake.
 - c. Curb Seal: Rubber seal between fan and roof curb.
 - d. Dampers:
 - 1) Type: Gravity.
 - 2) Factory designed to prevents outside air from entering back into building when fan is off.
 - 3) Galvanized frames with pre-punched mounting holes.
 - e. Hood Insulation or Coating: Provide 1/2-inch (12.7 mm) fiberglass insulation lining or anti-condensate coating to prevent condensation and reduce sound levels.
 - f. Insect Screen:
 - 1) Construct of fine mesh aluminum.
 - 2) Fitted to top of throat to prevent entry of insects.
 - 3) Coating: Thermo-setting polyester urethane.
 - g. Tie-Down Points: Aluminum brackets located on hood supports to secure fan in heavy wind applications.

B. Spun Aluminum Intake and Relief Gravity Ventilator:

1. Manufacturers:
 - a. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
2. General:
 - a. Provide low silhouette configuration for intake applications with natural gravity or negative pressure system.
 - b. Performance ratings and factory testing in accordance with AMCA 511 and AMCA 550.
 - c. Suitable for non-ducted applications.
 - d. Equipment to bear permanently affixed manufacturer's nameplate listing model and serial number.
3. Hood:
 - a. Material: Aluminum.
 - b. Internal structure constructed of galvanized steel.
4. Birdscreen:
 - a. Construction: 1/2 inch (12.7 mm) galvanized mesh.
 - b. Horizontally mounted across hood intake area.
5. Housing:
 - a. Curb Cap:
 - 1) Construction: Aluminum.
 - 2) Integral deep spun inlet venturi with pre-punched mounting holes to ensure correct attachment to roof.
6. Options/Accessories:
 - a. Roof Curbs:
 - 1) Flat Roofs:

- a) Welded, straight side curb with flashing flange and wood nailer.
 - b) Tabbed and riveted curb with 45 degree cant and wood nailer.
- b. Curb Seal: Rubber seal between fan and roof curb.
- c. Factory Finish: Polyester meeting or exceeding the chemical resistance properties of air dry phenolic.
- d. Flashing Flange:
 - 1) Construction:
 - a) Aluminum.
 - b) Pre-punched holes for installation without a roof curb.
- e. Hood Insulation: Lined with 1/2 inch (12.7 mm) fiberglass insulation to prevent condensation and reduce sound levels.
- f. Insect Screen:
 - 1) Fine mesh aluminum construction.
- g. Tie-Down Points: Aluminum brackets located on hood supports to secure fan in heavy wind applications.
- h. Reducer/Adapter:
 - 1) Material: Aluminum.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers and grilles and registers, despite whether dampers are specified as part of diffuser, or grille and register assembly.
- E. Paint ductwork visible behind air outlets and inlets matte black, see Section 099123.

END OF SECTION 233700

SECTION 237416 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Packaged, intermediate-capacity, rooftop air-conditioning units.

1.2 REFERENCE STANDARDS

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

1.4 QUALITY ASSURANCE

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect units from physical damage by storing off site until roof mounting curbs are in place and ready for immediate installation of units.

1.6 WARRANTY

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Trane Technologies, PLC: www.trane.com/#sle.

2.2 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. General: Roof mounted units having electric heating elements electric heating elements and electric refrigeration that are 25 tons and larger in capacity.
- B. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, electric heating elements, electric heating elements, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.
- C. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) no greater than that allowed by federal code

2.3 CASING

- A. Cabinet: Steel with baked enamel finish, including access panels with screwdriver-operated flush, cam type fasteners. Structural members to be minimum 18 gauge, 0.0478 inch (1.21 mm), with access doors or panels of minimum 20 gauge, 0.0359 inch (0.91 mm).
- B. Insulation: 2-inch (50 mm) thick, neoprene-coated glass fiber with edges protected from erosion.

2.4 FANS

2.5 ELECTRIC HEATING COIL

- A. Finned tube heating elements easily accessible with automatic reset thermal cut-out. Provide with built-in magnetic contactors, galvanized steel frame, control circuit transformer and fuse, manual reset thermal cut-out, airflow proving device, pilot duty toggle switch, load fuses.
- B. Controls: Start supply fan before electric elements are energized and continue operating until air temperature reaches minimum setting, with switch for continuous fan operation.

2.6 EVAPORATOR COIL

- A. Provide copper tube aluminum fin coil assembly with galvanized drain pan and connection.

2.7 CONDENSER COIL

- A. Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.
- B. Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Provide high efficiency fan motors.
- C. Provide refrigerant pressure switches to cycle condenser fans.

2.8 COMPRESSORS

- A. Provide hermetic compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.
- B. Five minute timed off circuit to delay compressor start.

2.9 AIR FILTERS:

- A. 2-inch (50 mm) thick, glass fiber disposable media in metal frames.

2.10 AIRFLOW MEASUREMENT

2.11 OPERATING CONTROLS - VARIABLE VOLUME UNITS

- A. Control cooling by cycling compressors, cylinder unloading, and hot gas bypass.
- B. Control logic to allow supply air reset under low load or airflow conditions.

2.12 ROOF CURBS

PART 3 EXECUTION

SECTION 238126.13 - SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Air-source heat pumps.
- B. Air cooled condensing units.
- C. Indoor air handling (fan and coil) units for ducted systems.
- D. Indoor air handling (fan and coil) units for ductless systems.
- E. Controls.

1.2 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2023.
- B. AHRI 520 - Performance Rating of Positive Displacement Condensing Units; 2004.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2024, with Addendum (2025).
- D. ASHRAE Std 23 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units; 2022.
- E. NEMA MG 00001 - Motors and Generators; 2024.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- G. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.
- H. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.
- I. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Trane Technologies, PLC; _____: www.trane.com/#sle.

2.2 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
1. Heating: Electric resistance heating.
 2. Cooling: Outdoor electric condensing unit with evaporator coils in multiple ductless indoor units ("mini-split").
 3. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.

2.3 INDOOR AIR HANDLING UNITS FOR DUCTED SYSTEMS

- A. Manufacturers:
1. Trane Technologies, PLC; _____: www.trane.com/#sle.
- B. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
1. Air Flow Configuration: Upflow.
 2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
- C. Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.
1. Motor: NEMA MG 1; 1750 rpm single speed, permanently lubricated, hinge mounted.
- D. Air Filters: 1 inch (25 mm) thick glass fiber, disposable type arranged for easy replacement.
- E. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
 2. Manufacturers: System manufacturer.

2.4 INDOOR AIR HANDLING UNITS FOR DUCTLESS SYSTEMS

- A. Manufacturers:

1. Trane Technologies, PLC; _____: www.trane.com/#sle.
- B. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
 1. Location: Ceiling.
 2. Cabinet: Galvanized steel.
 - a. Finish: White.
 3. Fan: Line-flow fan direct driven by a single motor.
 4. Filter return air with washable, antioxidant pre-filter and a pleated anti-allergy enzyme filter.
- C. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
 2. Manufacturer: System manufacturer.

2.5 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
 1. Comply with AHRI 210/240.
 2. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) no greater than that allowed by federal code.
 3. Refrigerant: R-454B.
 4. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL 207.
- B. Compressor: Hermetic, two speed 1800 and 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high-pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
- D. Accessories: Filter drier, high-pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
 1. Provide thermostatic expansion valves.
- E. Operating Controls:
 1. Control by room thermostat to maintain room temperature setting.
 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig (1965 kPa) and off when pressure drops below 140 psig (965 kPa) for operation to 0 degrees F (-18 degrees C).

- F. Mounting Pad: Precast concrete parking bumpers, minimum 4 inches (100 mm) square; minimum of two located under cabinet feet.

2.6 ACCESSORY EQUIPMENT

- A. Room Thermostat: Wall-mounted, electric solid state microcomputer based room thermostat with remote sensor to maintain temperature setting; low-voltage; with following features:
 - 1. System selector switch (heat-off-cool) and fan control switch (auto-on).
 - 2. Automatic switching from heating to cooling.
 - 3. Preferential rate control to minimize overshoot and deviation from setpoint.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.
- C. Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B. Install in accordance with NFPA 90A and NFPA 90B.
- C. Install refrigeration systems in accordance with ASHRAE Std 15.

END OF SECTION 238126.13

SECTION 238129 - VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Air-source outdoor units.
- B. Refrigerant piping.
- C. Refrigerant branch units.
- D. Indoor units.

1.2 RELATED REQUIREMENTS

- A. Section 232300 - Refrigerant Piping.

1.3 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2023.
- B. AHRI 1230 - Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment; 2021.
- C. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures; Most Recent Edition Cited by Referring Code or Reference Standard.
- D. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2024, with Addendum (2025).
- E. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants; 2024, with Addendum (2025).
- F. ITS (DIR) - Directory of Listed Products; Current Edition.
- G. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.

- B. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings indicated in Contract Documents:
1. Outdoor Units:
 - a. Refrigerant Type and Size of Charge.
 - b. Output and Input Cooling Capacity: Btu/h (W).
 - c. Output and Input Heating Capacity: Btu/h (W).
 - d. Operating Temperature Range, Cooling and Heating.
 - e. Fan Capacity: Flow in cfm (L/sec) with respective fan curves.
 - f. External Static Pressure (ESP): In-wc (Pa).
 - g. Sound Pressure Level: dB(A).
 - h. Electrical Data: Complete including motor size.
 - i. Maximum number of indoor units that can be served.
 - j. Maximum refrigerant piping run from outdoor unit to indoor unit(s).
 - k. Maximum height difference between outdoor unit to Indoor unit(s), both above and below.
 2. Indoor Units:
 - a. Output and Input Cooling Capacity: Btu/h (W).
 - b. Output and Input Heating Capacity: Btu/h (W).
 - c. Fan Capacity: Flow in cfm (L/sec) with respective fan curves.
 - d. External Static Pressure (ESP): In-wc (Pa).
 - e. Electrical Data: Complete including motor size.
 - f. Maximum Lift of Built-in Condensate Pump.
 3. Control Panels: Complete data of controllers, input-output points, and zones.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.6 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Compressors: Provide manufacturer's warranty for 6 years from date of installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Mitsubishi Electric Trane HVAC US, LLC; _____: www.metahvac.com/#sle.

2.2 VARIABLE REFRIGERANT FLOW SYSTEM

- A. Minimum System Requirements:
1. System Testing, Capacity Rating, and Performance:
 - a. AHRI 1230 when cooling capacity is equal or greater than 65,000 Btu/h (19 kWh).
 - b. AHRI 210/240 when cooling capacity is below 65,000 Btu/h (19 kWh).
 2. Safety Certification: Bear UL 1995 tested and ITS (DIR) listed certification label.

3. Outdoor Units: Furnish installation and surface support hardware products in accordance with ASCE 7 for wind restraint.
4. Cooling Mode Interior Performance:
 - a. Daytime Setpoint: 68 degrees F (20 degrees C), plus or minus 2 degrees F (1 degrees C).
 - b. Setpoint Range: 57 degrees F (14 degrees C) to 77 degrees F (25 degrees C).
 - c. Night Setback: 78 degrees F (25 degrees C).
 - d. Interior Relative Humidity: 20 percent, maximum.

2.3 AIR-SOURCE OUTDOOR UNITS

A. Manufacturers:

1. Air Conditioner, Cooling Outdoor Units:
2. Heat Pump, Cooling or Heating Outdoor Units:
 - a. Mitsubishi Electric Trane HVAC US, LLC; _____: www.metahvac.com/#sle.

B. Air Conditioning Type:

1. DX refrigeration unit piped to one or more compatible indoor units either directly or indirectly through one or more intermediate refrigeration branch units.

C. Unit Cabinet:

1. Capable of being installed with wiring and piping to the left, right, rear or bottom.
2. Designed to allow side-by-side installation with minimum spacing and vibration isolation.
3. Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
4. Sound Pressure Level: 55 dB measured at 3 feet (one meter) from front of unit.

D. Heat Sink Side:

1. Condenser Fans:
 - a. Provide minimum of 2 fans for each condenser within the outdoor unit.
 - b. Minimum External Static Pressure: Factory set at 0.12 in-wc (30 Pa).
 - c. Fan Type: Vertical discharging, direct-driven propeller type with variable speed operation using DC-controlled ECM motors mechanically connected using permanently lubricated bearings having whole assembly protected with fan guards.
2. Condenser Coils:
 - a. Hi-X seamless copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.

E. Refrigeration Side:

1. Factory assembled and wired with instrumentation, switches, and controller(s) to handle unit specifics with direct coordination of remote controller(s) from indoor unit(s).
2. Refrigeration Circuit: ECM driven dual scroll compressors, fans, condenser heat sink coil, expansion valves, solenoid valves, distribution headers, capillaries, filters, shutoff valves, oil separators, service ports, and refrigerant regulator.
3. Variable Volume Control: Modulate compressed refrigerant capacity automatically to maintain constant suction and condensing pressures under varying refrigerant volume required to handle remote loads. Include defrost control.

4. Provide refrigerant subcooling to ensure the liquid refrigerant does not flash when supplying to use indoor units.
5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle, oil return, or defrost is not permitted due to potential reduction in space temperature.
6. Power Failure Mode: Automatically restarts operation after power failure without loss of programmed settings.
7. Safety Devices: High pressure sensor with cut-out switch, low pressure sensor with cut-out switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, overcurrent protection for the inverter and antirecycling timers.
8. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.

F. Local Controls:

G. Power:

1. Electrical Requirement: 208 to 230 VAC, 3-phase, 60 Hz.
2. Outdoor Mounted: Provide fused NEMA EN 10250 Type 4X disconnect switch.

2.4 REFRIGERANT PIPING

- A. Two-Pipe Run: Provide low-pressure vapor and high-pressure vapor gas pipes for each indoor unit selected for seasonal heating or cooling service.
- B. Three-Pipe Run: Provide low-pressure vapor, high-pressure vapor gas, and liquid pipes for each indoor unit selected for off-season heating and cooling changeover service.
- C. Refrigerant Flow Balancing: Provide refrigerant piping joints and headers specifically designed to ensure proper refrigerant balance and flow for optimum system capacity and performance; T-style joints are prohibited.

2.5 REFRIGERANT BRANCH UNITS

- A. Manufacturers:
 1. Mitsubishi Electric Trane HVAC US, LLC; _____: www.metahvac.com/#sle.
- B. Outdoor unit interface to handle two or more indoor units required to do automatic off-season heating and cooling changeover.
- C. Concealed box consisting internally-piped refrigeration loops, subcooling heat exchanger, and other devices coordinated by electronic valves to facilitate off-season load management between outdoor and indoor units.
- D. Minimum Requirements:
 1. Control direction of refrigerant flow using electronic expansion valves; use of solenoid valves for changeover and pressure equalization is not permitted due to refrigerant noise; use of multi-port branch selector boxes is not permitted unless spare ports are provided for redundancy.

2. Provide one electronic expansion valve for each downstream indoor unit served except when multiple indoor units are connected, provide balancing joints in downstream piping to keep total capacity within branch unit capacity.
3. Energize subcooling heat exchanger during simultaneous heating and cooling service.
4. Casing: Galvanized steel sheet with flame and heat resistant foamed polyethylene sound and thermal insulation.
5. Refrigerant Connections: Braze type.
6. Condensate Drainage: Provide unit that does not require condensate drainage.

2.6 INDOOR UNITS

A. Manufacturers:

B. Minimum Unit Requirements:

1. DX Evaporator Coil:
 - a. Copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
 - b. 2-, 3-, or 4-row cross fin design with 14 to 17 fins per inch and flare end-connections.
 - c. Provide thermistor on liquid and gas lines wired into local controller.
 - d. Refrigerant circuits factory-charged with dehydrated air for field charging.
2. Fan Section:
 - a. Variable or three-speed ECM fan with automatic airflow adjustment; external static pressure selectable during commissioning.
 - b. Thermally protected, direct-drive motor with statically and dynamically balanced fan blades.
 - c. Minimum-adjustable external static pressure 0.32 in-wc (80 Pa); provide for mounting of field-installed ducts.
3. Local Unit Controls:
 - a. Temperature Control: Return air control using thermistor tied to computerized Proportional-Integral-Derivative (PID) control of superheat.
 - b. Temperature Zones:
 - 1) Single Indoor Unit: Set served space(s) as the local temperature zone.
 - 2) Multiple Indoor Units: For large zones, group and coordinate related indoor units with served spaces as the local temperature zone with each indoor unit as sub-zone.
4. Return Air Filter:
5. Condensate:
 - a. Built-in condensate drain pan with PVC drain connection for drainage.
 - b. Units With Built-In Condensate Pumps: Provide condensate safety shutoff and alarm.
 - c. Units Without Built-In Condensate Pump: Provide built-in condensate float switch and wiring connections.
6. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.

C. Ceiling-Recessed Cassette, Indoor Units:

1. Ceiling mount, 4-way, 2-way, or 1-way supply air flow units with central return air grill, DX coil, tubed drain pan, and built-in controls with thermostat remotely coordinated by outdoor air unit to maintain local air temperature setpoint.
2. Cabinet Height: Maximum of 10 inches (250 mm) above face of ceiling.
3. Exposed Housing: White, impact resistant, with washable decoration panel.

4. Supply Airflow Adjustment:
 - a. Horizontally and vertically adjustable dampers with electronic actuators.
 - b. Four-way distribution field-modifiable to 3-way and 2-way airflow.
 - c. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
 5. Return Air Filter: Manufacturer's standard.
 6. Sound Pressure Range: Between 28 to 33 dB(A) at low speed measured at 5 feet (1.5 m) below the unit.
 7. Fan: Direct-drive turbo type, with motor output range of 1/16 to 1/8 hp (45 to 90 W).
 8. Condensate Pump: Built-in with minimum lift of 21 inches (533 mm).
 9. Fresh Air Intake: Provide side-mounted outdoor air intake duct connection.
- D. Wall Mounted, Indoor Units:
1. Manufacturers:
 - a. Mitsubishi Electric Trane HVAC US, LLC; _____: www.metahvac.com/#sle.
 2. DX coil, tubed drain pan, and built-in controls with thermostat remotely coordinated by outdoor air unit to maintain local air temperature setpoint.
 3. Variable or three-speed ECM cross-flow fan with automatic airflow adjustment; external static pressure selectable during commissioning.
 4. Return Air Filter: Manufacturer's standard.
 5. Provide exposed unit casing with removable front grille; foamed polystyrene and polyethylene sound insulation; wall mounting plate; polystyrene condensate drain pan.
 6. Airflow Control: Auto-swing louver that closes automatically when unit stops; five (5) steps of discharge angle, set using remote controller; upon restart, discharge angle defaults to same angle as previous operation.
 7. Sound Pressure Range: Measured at low speed at 3.3 feet (1 m) below and away from unit.
 8. Condensate Drain Connection: Back, with piping concealed in wall.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.
- B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install refrigerant piping in accordance with equipment manufacturer's instructions.
- C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).
- D. Coordinate with installers of systems and equipment connecting to this system.

3.3 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform system startup.
- B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- C. Adjust equipment for proper operation within manufacturer's published tolerances.

END OF SECTION 238129

SECTION 260010 - SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements generally applicable to all electrical Work on the Project, including but not limited to Work specified in Divisions 26, 27, and 28.
- B. Related Requirements:
 - 1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
 - 2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
 - 3. Section 013100 "Project Management and Coordination" specifies preinstallation conference procedures.

1.2 REFERENCES

- A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:
 - 1. 8P8C: An 8-position 8-contact modular jack.
 - 2. A: Ampere, unit of electrical current.
 - 3. AC or ac: Alternating current.
 - 4. AFCI: Arc-fault circuit interrupter.
 - 5. AGC: Automatic gain control.
 - 6. AIC: Ampere interrupting capacity.
 - 7. AL, Al, or ALUM: Aluminum.
 - 8. ASD: Adjustable-speed drive.
 - 9. ATP: Acceptance test procedure.
 - 10. ATS: Automatic transfer switch.
 - 11. A/V: Audio/visual.
 - 12. AWG: American wire gauge; see ASTM B258.
 - 13. BAS: Building automation system.
 - 14. BDA: Bi-directional amplifier.
 - 15. BIL: Basic impulse insulation level.
 - 16. BIM: Building information modeling.
 - 17. BMS: Building management system.
 - 18. BNC: Bayonet Neill-Concelman - type of connector.
 - 19. B/W: Black and white.
 - 20. CAD: Computer-aided design or drafting.
 - 21. CATV: Community antenna television.
 - 22. CB: Circuit breaker.
 - 23. CCD: Charge-coupled device.
 - 24. CCTV: Closed-circuit television.
 - 25. cd: Candela, the SI fundamental unit of luminous intensity.
 - 26. CO/ALR: Copper-aluminum, revised.
 - 27. COPS: Critical operations power system.

- 28. CU or Cu: Copper.
- 29. CU-AL or AL-CU: Copper-aluminum.
- 30. DACR: Digital alarm communicator receiver.
- 31. DACT: Digital alarm communicator transmitter.
- 32. DAS: Distributed antenna system.
- 33. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
- 34. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
- 35. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
- 36. dBm: Decibel absolute power with respect to 1 mW.
- 37. dBmV: Decibel absolute voltage with respect to 1 mV across identical impedance.
- 38. DC or dc: Direct current.
- 39. DCOA: Designated critical operations area.
- 40. DDC: Direct digital control (HVAC).
- 41. DGP: Data gathering panel.
- 42. DHCP: Dynamic host configuration protocol.
- 43. EGC: Equipment grounding conductor.
- 44. ELV: Extra-low voltage.
- 45. EMF: Electromotive force.
- 46. EMI: Electromagnetic interference.
- 47. EMP: Electrical maintenance program (operation and maintenance); electromagnetic pulse (transient analysis).
- 48. EPS: Emergency power supply.
- 49. EPSS: Emergency power supply system.
- 50. ERCES: Emergency responder communications enhancement system.
- 51. ESS: Energy storage system.
- 52. EV: Electric vehicle.
- 53. EVPE: Electric vehicle power export equipment.
- 54. EVSE: Electric vehicle supply equipment.
- 55. FACU: Fire-alarm control unit.
- 56. FAS: Fire-alarm system.
- 57. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
- 58. FCC: Federal Communications Commission; fire command center.
- 59. FLC: Full-load current.
- 60. ft: Foot.
- 61. ft-cd: Foot-candle, the antiquated U.S. standard unit of illuminance, equal to one international candle measured at a distance of one foot, that was superseded in 1948 by the unit "footcandle" when the SI unit candela (cd) replaced the international candle; see "fc."
- 62. FTP: File transfer protocol.
- 63. FXO: Foreign exchange office.
- 64. GEC: Grounding electrode conductor.
- 65. GFCI: Ground-fault circuit interrupter.
- 66. GFPE: Ground-fault protection of equipment.
- 67. GND: Ground.
- 68. GROL: General Radiotelephone Operator License (FCC).
- 69. H.323: Audio and video protocol.
- 70. HACR: Heating, air conditioning, and refrigeration.
- 71. HDPE: High-density polyethylene.
- 72. HID: High-intensity discharge.

- 73. HP or hp: Horsepower.
- 74. HVAC: Heating, ventilating, and air conditioning.
- 75. Hz: Hertz.
- 76. I&TFAS: Inspection and testing of fire-alarm system.
- 77. IB-PSC: In-building public safety communications.
- 78. IBT: Intersystem bonding termination.
- 79. ICT: Information and communications technology.
- 80. IDC: Initiating device circuit.
- 81. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
- 82. I/O: Input/output.
- 83. IP: Ingress protection rating (enclosures); Internet protocol (communications).
- 84. IR: Infrared.
- 85. IS: Intrinsically safe.
- 86. IT&R: Inspecting, testing, and repair.
- 87. ITE: Information technology equipment.
- 88. kAIC: Kiloampere interrupting capacity.
- 89. kcmil or MCM: One thousand circular mils.
- 90. kV: Kilovolt.
- 91. kVA: Kilovolt-ampere.
- 92. kvar: Kilovolt-ampere reactive.
- 93. kW: Kilowatt.
- 94. kWh: Kilowatt-hour.
- 95. LAN: Local area network.
- 96. lb: Pound (weight).
- 97. lbf: Pound (force).
- 98. LCD: Liquid-crystal display.
- 99. LCDI: Leakage-current detector-interrupter.
- 100. LED: Light-emitting diode.
- 101. Li-ion: Lithium-ion.
- 102. lm: Lumen, the SI-derived unit of luminous flux.
- 103. LNG: Liquefied natural gas.
- 104. LP-Gas: Liquefied petroleum gas.
- 105. LRC: Locked-rotor current.
- 106. LTE: Long-term evolution (mobile device technology standard).
- 107. LV: Low voltage.
- 108. lx: Lux, the SI-derived unit of illuminance equal to one lumen per square meter.
- 109. m: Meter.
- 110. MATV: Master antenna television.
- 111. MCC: Motor-control center.
- 112. MDC: Modular data center.
- 113. MG set: Motor-generator set.
- 114. MIDI: Musical instrument digital interface.
- 115. MLO: Main lugs only.
- 116. MPEG: Moving Picture Experts Group.
- 117. MPEG-2: Abbreviation for the ISO/IEC Moving Picture Experts Group's standard for generic coding of moving pictures and associated audio information (ISO/IEC 13818) released in 1995 and used for most over-the-air and satellite broadcast digital television.
- 118. MPEG-4: Abbreviation for the ISO/IEC Moving Picture Experts Group's standard framework for coding of audio-visual objects (ISO/IEC 14496) released in 1999, with digital rights management and more advanced compression algorithms than MPEG-2.
- 119. MOV: Metal-oxide varistor.
- 120. MV: Medium voltage.
- 121. MVA: Megavolt-ampere.
- 122. mW: Milliwatt.
- 123. MW: Megawatt.

- 124. MWh: Megawatt-hour.
- 125. NAC: Notification appliance circuit.
- 126. N.C.: Normally closed.
- 127. NFC: Near field communications.
- 128. NICET: National Institute for Certification in Engineering Technologies, a division of the National Society of Professional Engineers.
- 129. Ni-Cd: Nickel-cadmium.
- 130. Ni-MH: Nickel-metal hydride.
- 131. NIU: Network interface unit.
- 132. N.O.: Normally open.
- 133. NPT: National (American) standard pipe taper.
- 134. NTSC: National Television System Committee.
- 135. OCPD: Overcurrent protective device.
- 136. ONT: Optical network terminal.
- 137. PC: Personal computer.
- 138. PCS: Power conversion system.
- 139. PCU: Power-conditioning unit.
- 140. Percent obs/ft (percent obs/m): Percent obscuration per unit distance; unit of measure for sensitivity of smoke detectors.
- 141. PF or pf: Power factor.
- 142. PHEV: Plug-in hybrid electric vehicle.
- 143. PIR: Passive infrared.
- 144. PLC: Programmable logic controller.
- 145. PLFA: Power-limited fire alarm.
- 146. PoE: Power over Ethernet.
- 147. POTS: Plain old telephone service. See "public switched telephone network" definition.
- 148. PSTN: Public switched telephone network.
- 149. PTZ: Pan-tilt-zoom.
- 150. PV: Photovoltaic.
- 151. PVC: Polyvinyl chloride.
- 152. pW: Picowatt.
- 153. RAID: Redundant array of inexpensive disks; redundant array of independent disks.
- 154. RAM: Random-access memory.
- 155. RAT: Radio alarm transmitter.
- 156. REX: Request-to-exit.
- 157. RF: Radio frequency.
- 158. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
- 159. RMS or rms: Root-mean-square.
- 160. RPM or rpm: Revolutions per minute.
- 161. SCADA: Supervisory control and data acquisition.
- 162. SCCR: Short-circuit current rating.
- 163. SCR: Silicon-controlled rectifier.
- 164. SIP: Session initiation protocol.
- 165. SLC: Signaling-line circuit.
- 166. SPD: Surge protective device.
- 167. SPDT: Single pole, double throw.
- 168. sq.: Square.
- 169. SWD: Switching duty.
- 170. TCP/IP: Transmission Control Protocol/Internet Protocol.
- 171. TEFC: Totally enclosed fan-cooled.
- 172. TR: Tamper resistant.
- 173. TVSS: Transient voltage surge suppressor.
- 174. UHF: Ultra-high frequency.
- 175. UL: (standards) UL Standards & Engagement Inc.; (product categories) UL, LLC.
- 176. UL CCN: UL Category Control Number.

- 177. UPS: Uninterruptible power supply.
- 178. USB: Universal serial bus.
- 179. UTC: Coordinated universal time.
- 180. UV: Ultraviolet.
- 181. V: Volt, unit of electromotive force.
- 182. V(ac): Volt, alternating current.
- 183. V(dc): Volt, direct current.
- 184. VA: Volt-ampere, unit of complex electrical power.
- 185. VAR: Volt-ampere reactive, unit of reactive electrical power.
- 186. VFC: Variable-frequency controller.
- 187. VOM: Volt-ohm-multimeter.
- 188. VoIP: Voice over Internet Protocol.
- 189. VPN: Virtual private network.
- 190. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
- 191. VU: Volume unit.
- 192. W: Watt, unit of real electrical power.
- 193. WAN: Wide area network.
- 194. Wh: Watt-hour, unit of electrical energy usage.
- 195. WPT: Wireless power transfer.
- 196. WPTE: Wireless power transfer equipment.
- 197. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

- 1. EMT: Electrical metallic tubing.
- 2. EMT-A: Aluminum electrical metallic tubing.
- 3. EMT-S: Steel electrical metallic tubing.
- 4. EMT-SS: Stainless steel electrical metallic tubing.
- 5. ENT: Electrical nonmetallic tubing.
- 6. EPEC: Electrical HDPE underground conduit (thin wall).
- 7. EPEC-A: Type A electrical HDPE underground conduit.
- 8. EPEC-B: Type B electrical HDPE underground conduit.
- 9. ERMC: Electrical rigid metal conduit.
- 10. ERMC-A: Aluminum electrical rigid metal conduit.
- 11. ERMC-S: Steel electrical rigid metal conduit.
- 12. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
- 13. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
- 14. ERMC-SS: Stainless steel electrical rigid metal conduit.
- 15. FMC: Flexible metal conduit.
- 16. FMC-A: Aluminum flexible metal conduit.
- 17. FMC-S: Steel flexible metal conduit.
- 18. FMT: Steel flexible metallic tubing.
- 19. FNMC: Flexible nonmetallic conduit. See "LFNC."
- 20. HDPE: HDPE underground conduit (thick wall).
- 21. HDPE-40: Schedule 40 HDPE underground conduit.
- 22. HDPE-80: Schedule 80 HDPE underground conduit.
- 23. IMC: Steel electrical intermediate metal conduit.
- 24. LFMC: Liquidtight flexible metal conduit.
- 25. LFMC-A: Aluminum liquidtight flexible metal conduit.
- 26. LFMC-S: Steel liquidtight flexible metal conduit.
- 27. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
- 28. LFNC: Liquidtight flexible nonmetallic conduit.
- 29. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
- 30. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.

31. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
32. PVC: Rigid PVC conduit.
33. PVC-40: Schedule 40 rigid PVC conduit.
34. PVC-80: Schedule 80 rigid PVC Conduit.
35. PVC-A: Type A rigid PVC concrete-encased conduit.
36. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
37. RGS: See ERM-C-S-G.
38. RMC: See ERM-C.
39. RTRC: Reinforced thermosetting resin conduit.
40. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
41. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
42. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
43. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
44. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.
13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.
16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMUC: Under-carpet communications wire and cable.
19. CMX: Communications cable, limited use.
20. DG: Distributed generation cable.
21. FC: Flat cable.
22. FCC: Flat conductor cable.
23. FPL: Power-limited fire-alarm cable.
24. FPLP: Power-limited fire-alarm plenum cable.
25. FPLR: Power-limited fire-alarm riser cable.
26. IGS: Integrated gas spacer cable.
27. ITC: Instrumentation tray cable.
28. ITC-ER: Instrumentation tray cable, exposed run.
29. MC: Metal-clad cable.
30. MC-FPL/FPLR/FPLP: Metal-clad cable containing FPL, FPLR, or FPLP.
31. MC-HL: Metal-clad cable, hazardous location.
32. MI: Mineral-insulated, metal-sheathed cable.
33. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
34. MV: Medium-voltage cable.

- 35. NM: Nonmetallic sheathed cable.
- 36. NMC: Nonmetallic sheathed cable with corrosion-resistant nonmetallic jacket.
- 37. NMS: Nonmetallic sheathed cable with signaling, data, and communications conductors, plus power or control conductors.
- 38. NPLF: Non-power-limited fire-alarm circuit cable.
- 39. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
- 40. NPLFR: Non-power-limited fire-alarm circuit riser cable.
- 41. NUCC: Nonmetallic underground HDPE conduit with conductors.
- 42. OFC: Conductive optical fiber general-purpose cable.
- 43. OFCG: Conductive optical fiber general-purpose cable.
- 44. OFCP: Conductive optical fiber plenum cable.
- 45. OFCR: Conductive optical fiber riser cable.
- 46. OFN: Nonconductive optical fiber general-purpose cable.
- 47. OFNG: Nonconductive optical fiber general-purpose cable.
- 48. OFNP: Nonconductive optical fiber plenum cable.
- 49. OFNR: Nonconductive optical fiber riser cable.
- 50. P: Marine shipboard cable.
- 51. PLTC: Power-limited tray cable.
- 52. PLTC-ER: Power-limited tray cable, exposed run.
- 53. PV: Photovoltaic cable.
- 54. RHH: (high heat) Thermoset rubber, heat-resistant cable.
- 55. RHW: Thermoset rubber, moisture-resistant cable.
- 56. SA: Silicone rubber cable.
- 57. SE: Service-entrance cable.
- 58. SER: Service-entrance cable, round.
- 59. SEU: Service-entrance cable, flat.
- 60. SIS: Thermoset cable for switchboard and switchgear wiring.
- 61. TBS: Thermoplastic cable with outer braid.
- 62. TC: Tray cable.
- 63. TC-ER: Tray cable, exposed run.
- 64. TC-ER-HL: Tray cable, exposed run, hazardous location.
- 65. THW: Thermoplastic, heat- and moisture-resistant cable.
- 66. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
- 67. THHW: Thermoplastic, heat- and moisture-resistant cable.
- 68. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
- 69. TW: Thermoplastic, moisture-resistant cable.
- 70. UF: Underground feeder and branch-circuit cable.
- 71. USE: Underground service-entrance cable.
- 72. XHH: Cross-linked polyethylene, heat-resistant cable.
- 73. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Abbreviations and Acronyms for Electrical Flexible Cord Types:

- 1. SEO: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
- 2. SEOW: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
- 3. SEOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
- 4. SEOWW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.

5. SJEO: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
6. SJEOW: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
7. SJEOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
8. SJEOWW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
9. SJO: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp locations.
10. SJOW: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
11. SJOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp locations.
12. SJOWW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
13. SJTO: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
14. SJTOW: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
15. SJTOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
16. SJTOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
17. SO: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp locations.
18. SOW: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
19. SOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp locations.
20. SOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
21. STO: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
22. STOW: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.
23. STOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
24. STOWW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.

E. Abbreviations for Communications Spaces:

1. EF: Entrance facility; generally serves campus or building. EF may include an ER.
2. ER: Equipment room; generally serves campus or building.
3. TE: Telecommunications enclosure; generally serves a single tenant or floor.
4. TR: Telecommunications room; generally serves a single tenant or floor.

F. Abbreviations for Grounding and Bonding:

1. BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.

2. PBB: Primary bonding busbar; located in main distribution frame room, ideally near electrical service entrance.
3. RBB: Rack bonding busbar; located in equipment cabinets and racks.
4. SBB: Secondary bonding busbar; located in intermediate distribution frame rooms.
5. TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.
6. TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.
7. TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.
8. UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

G. Definitions:

1. 8-Position 8-Contact (8P8C) Modular Jack: An unkeyed jack with up to eight contacts commonly used to terminate twisted pair and multiconductor Ethernet cable. Also called a "TIA-1096 miniature 8-position series jack" (8PSJ), or an "IEC 8877 8-pole jack."
 - a. Be careful when suppliers use "RJ45" generically. Obsolete RJ45 jacks used for analog telephone cables have rejection keys. 8P8C jacks used for digital telephone cables and Ethernet cables do not have rejection keys.
2. Agile Receiver: A broadband receiver that can be tuned to any desired channel.
3. Backbone: Primary segment of ERCES between donor antenna and distribution cabling.
4. Basic Impulse Insulation Level (BIL): Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
5. 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.
6. Broadcast Media: Loudspeakers, radios, cellular phones, and other media that will carry the selected message to the selected audience.
7. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
8. 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.
9. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
10. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
11. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
12. Conductive Cable: Cable containing non-current-carrying electrically conductive members such as metallic strength members and metallic vapor barriers.
13. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable,

- or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
14. Conduit: A structure containing one or more duct raceways.
 15. Control Unit: A system component that monitors inputs and controls outputs through various types of circuits.
 - a. Autonomous Control Unit (ACU): The primary control unit for an in-building mass notification system (MNS).
 - b. Emergency Communications Control Unit (ECCU): A system capable of sending mass notification messages to individual buildings, zones of buildings, individual outdoor loudspeaker arrays, or zones of outdoor loudspeaker arrays; or a building, multiple buildings, outside areas, or a combination of these.
 - c. Fire-alarm control unit (FACU).
 - d. Wireless Control Unit: A component that transmits/receives and processes wireless signals.
 16. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."
 17. Direct Buried: Installed underground without encasement in concrete or other protective material.
 18. Downlink: The signal from a base station to portable radios.
 19. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.
 20. Duct Raceway: A single enclosed raceway for conductors or cable.
 21. Electrical Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
 22. Emergency Communications System (ECS): A system for the protection of life by indicating the existence of an emergency situation and communicating information necessary to facilitate an appropriate response and action.
 - a. Distributed Recipient Mass Notification System (DRMNS): A system meant to communicate directly to targeted individuals and groups that might not be in a contiguous area.
 - b. Emergency Voice/Alarm Communications System (EVACS): Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as evacuation signals pertaining to an emergency, to the occupants of a building.
 - c. Mass Notification System (MNS): A system used to provide information and instructions to people in buildings or other spaces using intelligible voice communications and including visual signals, text, graphics, tactile, or other communication methods (in-building MNS); and could have the capability to provide real-time information to outdoor areas and to communicate with other notification systems provided for a campus, region, or global geographic setting (wide-area MNS).
 23. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that is designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety of human life.
 24. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:

- a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
 - b. Concrete Box: A box intended for use in poured concrete.
 - c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
 - d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
 - e. Cover Plate: A cover designed for protecting wiring devices installed in flush-mounted device boxes while permitting their safe operation; also called a faceplate or wallplate.
 - f. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
 - g. Device Box: A box with provisions for mounting a wiring device directly to the box.
 - h. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
 - i. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
 - j. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
 - k. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
 - l. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
 - m. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
 - n. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
 - o. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
 - p. Raised-Floor Box: A floor box intended for use in raised floors.
 - q. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
 - r. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
 - s. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
 - t. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
 - u. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.
25. Essential Electrical Systems: (healthcare facilities) Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility

- during disruption of normal power sources, and also to minimize disruption within the internal wiring system.
26. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.
- a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS1 and PS2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.
27. 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."
28. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
29. High Power Loudspeaker Array (HPLA): A product providing capability for voice and tone communication to large outdoor areas.
30. Jack: Also commonly called an "outlet," it is the fixed, female connector.
31. Jacket: A continuous nonmetallic outer covering for conductors or cables.
32. Local Operator Console (LOC): Equipment used by authorized personnel and emergency responders to activate and operate a mass notification system (MNS).
33. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.
34. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
35. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.
36. Monitoring: Acquisition, processing, communication, and display of system and equipment status data and event and alarm signals.
37. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
38. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
39. Nonsecure: Unlocked or open. (For doors and gates.)
40. 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. Also called "single-line diagram."
41. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
42. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
43. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
44. Protective Device: A device that senses when an abnormal current flow, abnormal voltage potential, or other abnormal electrical waveform exists and then disconnects the affected portion of the circuit from the system. Common protective devices include fuses, circuit breakers, relays, ground-fault circuit interrupters, and arc-fault circuit interrupters.

45. Public Switched Telephone Network (PSTN): Analog telephone technology that uses twisted pair cables from a telephone-provider central office for the transmission medium. "PSTN" refers to the telephone network; "POTS" refers to the individual subscriber line.
46. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
47. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
48. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
49. Secure: Closed and locked and with no unlock or open commands pending. (For doors and gates.)
50. Sheath: A continuous metallic covering for conductors or cables.
51. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
52. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
53. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
54. Uplink: The signal from a portable radio to the base station.
55. Voice over Internet Protocol (VoIP): Digital telephone packet technology that uses the internet for its transmission medium.
56. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
 - a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
 - b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
 - c. Extra-Low Voltage (ELV): Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
 - d. Low Voltage (LV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
 - e. Medium Voltage (MV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.
 - f. High Voltage: (1) (circuits) Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 69 kV but not exceeding 230 kV. (2) (safety) Having sufficient electromotive force to inflict bodily harm or injury.
57. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.
58. Zone. A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

1.3 COORDINATION

- A. Interruption of Existing Systems: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:
1. Notify Owner no fewer than seven days in advance of proposed interruption of electrical service.
 2. Do not proceed with interruption of electrical service without Owner's written permission.
 3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:
 - a. Electrical Services
 - 1) Exercising generators.
 - 2) Emergency lighting.
 - 3) Elevators.
 - 4) Fire-alarm systems.
 - b. Telephone Service
 - c. Internet Service
 - d. Security System
 - e. Fire alarm System
 4. Arrange to provide temporary emergency and standby systems so facility may remain occupied during the outage in accordance with requirements specified in Section 015000 "Temporary Facilities and Controls." Coordinate power requirements with Owner.

1.4 PREINSTALLATION MEETINGS

- A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than 10 days after Notice to Proceed. Agenda topics include, but are not limited to, the following:
1. Electrical installation schedule.
 2. Status of power system studies.
 3. Utility work coordination and class of service requests.
 4. Commissioning activities.
- B. Communications Preconstruction Conference: Schedule conference with Architect and Owner not later than 10 days after Notice to Proceed. Agenda topics include, but are not limited to, the following:
1. Installation schedule for communications systems.
 2. Utility services work coordination and monitoring service requests.
 3. Commissioning activities.
- C. Electronic Safety and Security Preconstruction Conference: Schedule conference with Architect and Owner not later than 10 days after Notice to Proceed. Agenda topics include, but are not limited to, the following:
1. Installation schedule for security, fire-alarm, and other life-safety systems.
 2. Value analysis proposals and requests for substitution of electronic safety and security equipment.
 3. Monitoring services work coordination and monitoring service requests.
 4. Commissioning activities.

5. Sustainability activities.

1.5 SEQUENCING

- A. Conduct and submit results of power system studies before submitting product data and Shop Drawings for electrical equipment. Refer to the 26 05 73 Power System Studies for additional requirements.
- B. Provide submittal schedule at or before the Electrical Preconstruction Conference. Notify engineer immediately of any deviations from expected submittal schedule.

1.6 ACTION SUBMITTALS

- A. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices, including restraints and bracing for control of seismic and wind loads, with other systems, equipment, and structural supports in the vicinity.
- B. Coordination Drawings for Ceiling Areas: Where indicated on drawings, provide reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," 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. Structural members to which equipment and suspension systems will be attached.
 3. Size and location of access panels on ceilings.
 4. Elevation, size, and route of sprinkler piping.
 5. Elevation, size, and route of plumbing piping.
 6. Elevation, size, and route of ductwork.
 7. Elevation, size, and route of cable tray.
 8. Elevation, size, and route of conduit.
 9. Elevation and size of wall-mounted and ceiling-mounted equipment.
 10. Access panels.
 11. Sprinklers.
 12. Air inlets and outlets.
 13. Control modules.
 14. Luminaires.
 15. Communications devices.
 16. Speakers.
 17. Security devices.
 18. Fire-alarm devices.
 19. Indicate clear dimensions for maintenance access in front of equipment.
 20. Indicate dimensions of fully open access doors.
- C. Coordination Drawings for Cable Tray Routing: Reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Elevation, size, and route of cable trays.
 2. Relationships between components and adjacent structural, electrical, and mechanical elements.
 3. Vertical and horizontal offsets and transitions.

4. Elevation and size of sleeves for wall, ceiling, and floor cable penetrations.
 5. Elevation of ceilings and size of ceiling tiles.
 6. Locations of access panels on ceilings.
 7. Locations where cable tray crosses or parallels sprinkler piping.
 8. Locations where cable tray crosses plumbing piping.
 9. Locations where cable tray crosses or parallels ductwork.
 10. Locations of access panels on ductwork.
 11. Locations where cable tray crosses conduit.
 12. Items blocking access around cable trays, including the following:
 - a. Light fixtures.
 - b. Speakers.
 - c. Fire-alarm devices.
 - d. Power outlets.
 - e. Wall-mounted equipment.
 - f. Equipment racks.
 - g. Furniture.
 - h. Door swings.
 - i. Building features.
 13. Indicate clear dimension between cable tray and walls or obstructions that are closer than 10 ft (3 m).
 14. Highlight locations where cable tray is greater than 3 ft (1 m) above ceilings. Explain how personnel access will be accommodated for cable tray maintenance.
- D. Coordination Drawings for Conduit Routing: 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.
- E. Coordination Drawings for Large Equipment Indoor Installations:
1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.
 2. Floor plan for entry floor and floor where equipment is located, drawn to scale, showing heavy equipment access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:
 - a. Dimensioned concrete bases, outlines of equipment, conduit entries, and grounding equipment locations.
 - b. If freight elevator must be used, indicate width and height of door and depth of car. Indicate if large equipment must be tipped to use elevator.
 - c. Dimensioned working clearances and dedicated areas below and around electrical equipment where obstructions and tripping hazards are prohibited.
 3. Reflected ceiling plans for entry floor and floor where equipment is located, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

- a. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, busways, and seismic bracing.
- b. Location of lighting fixtures, sprinkler piping and sprinklers, ducts and diffusers, and other obstructions, indicating available overhead clearance.
- c. Dimensioned working clearances and dedicated areas above and around electrical equipment where foreign systems and equipment are prohibited.

F. Coordination Drawings for Large Equipment Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:
 - a. Fences and walls, dimensioned concrete bases, outlines of equipment, conduit entries, and grounding and bonding locations.
 - b. Indicate clear dimensions for fence gates and wall openings.
 - c. Indicate depth and type of ground cover, and locations of trees, shrubbery, and other obstructions in access path.
 - d. Indicate clear height below tree branches, overhead lines, bridges, and other overhead obstructions in access path, or where cranes and hoists will be needed to handle large electrical equipment.
 - e. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, busways, and seismic bracing.
 - f. Dimensioned working clearances and dedicated areas around electrical equipment.

G. Coordination Drawings for Duct Banks:

1. Show duct profiles and coordination with other utilities and underground structures.
2. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

1.7 INFORMATIONAL SUBMITTALS

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:

1. Submission of power system studies.
2. Submission of specified coordination drawings.
3. Submission of action submittals specified in Division 26.
4. Orders placed for major electrical equipment.
5. Arrival of major electrical equipment on-site.
6. Preinstallation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.
10. Closing of walls and ceilings containing electrical Work.
11. System startup, testing, and commissioning activities for major electrical equipment.
12. System startup, testing, and commissioning activities for emergency lighting.
13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).

14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
 15. Requests for special inspections.
 16. Requests for inspections by authorities having jurisdiction.
- B. Installation Schedule for Communications Systems: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for installation of the communications Work to Owner and Architect including, but not limited to, milestone dates for the following activities:
1. Submission of specified coordination drawings.
 2. Submission of action submittals specified in Division 27.
 3. Orders placed for major equipment.
 4. Arrival of major equipment on-site.
 5. Preinstallation meetings specified in Division 27.
 6. Telephone and internet service outages.
 7. Telephone and internet service inspection and activation.
 8. Mockup reviews.
 9. Closing of walls and ceilings containing the communications Work.
 10. System startup, testing, and commissioning activities for communications equipment.
 11. System startup, testing, and commissioning activities for the Work specified in other divisions that depends on the Work specified in Division 27.
 12. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
 13. Requests for special inspections.
 14. Requests for inspections by authorities having jurisdiction.
- C. Installation Schedule for Security, Fire-Alarm, and Other Life-Safety Systems: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for installation of security, fire-alarm, and the other life-safety Work to Owner and Architect including, but not limited to, milestone dates for the following activities:
1. Submission of specified coordination drawings.
 2. Submission of action submittals specified in Division 28.
 3. Orders placed for major equipment.
 4. Arrival of major equipment on-site.
 5. Preinstallation meetings specified in Division 28.
 6. Security and fire-alarm system outages.
 7. Security and fire-alarm system inspection and activation.
 8. Mockup reviews.
 9. Closing of walls and ceilings containing the security and fire-alarm Work.
 10. System startup, testing, and commissioning activities for security and fire-alarm equipment.
 11. System startup, testing, and commissioning activities for fire-alarm interfaces with the Work specified in other divisions.
 12. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
 13. Requests for special inspections.
 14. Requests for inspections by authorities having jurisdiction.
- D. Welding certificates.
- E. Seismic Performance Certificates: Provide special certification for designated seismic systems as required to meet requirements specified in Section 018123 "Facility Seismic and Wind Criteria" for all designated seismic systems identified on the Drawings or in the Specifications.

1. Include the following information:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - d. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
 - e. Equipment manufacturer's written certification for each designated active electrical seismic device and system, stating that it will remain operable following the basis-of-design seismic criteria specified in Section 018123 "Facility Seismic and Wind Criteria."
 - f. Equipment manufacturer's written certification that components with hazardous contents maintain containment following the basis-of-design seismic criteria specified in Section 018123 "Facility Seismic and Wind Criteria."
 - g. Evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by qualified structural professional engineer.
- F. Wind Performance Certificates: Provide special certification for systems and components designated on the Drawings or in the Specifications to be subject to high wind exposure and impact damage.
 1. Include the following information:
 - a. Provide equipment manufacturer's written certification for each designated system and component, stating that it will remain in place and operable following the design wind event and comply with requirements of authorities having jurisdiction.
 - b. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.
- G. Qualification Statements:
 1. For qualified regional manufacturer.
 2. For structural professional engineer.
 3. For electrical professional engineer.
 4. For lighting professional engineer.
 5. For EPM specialist.
 6. For welder.
 7. For ERMCS-PVC raceway Installer.
 8. For medium-voltage cable Installer.
 9. For medium-voltage duct Installer.
 10. For medium-voltage equipment Installer.
 11. For electrical power monitoring Installer.
 12. For switchboard Installer.
 13. For EVSE Installer.
 14. For generator set Installer.
 15. For lightning protection system Installer.
 16. For theatrical lighting Installer.
 17. For exterior athletic lighting Installer.
 18. For power quality specialist.
 19. For electrical testing and inspecting agency and its on-site electrical testing supervisor.

20. For structural testing and inspecting agency.
21. For outdoor pole testing and inspecting agency.
22. For luminaire photometric testing laboratory.
23. For lighting testing and inspecting agency.
24. For fire-alarm system design professional.
25. For mass notification design professional.
26. For fire-alarm cable Installer and its on-site fire-alarm cable installation supervisor.
27. For security testing and inspecting agency and its on-site security testing supervisor.
28. For fire-alarm testing agency and its on-site fire-alarm testing supervisor.

1.8 CLOSEOUT SUBMITTALS

A. Facility EMP Binders:

1. Complete Set: On approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
2. Volumes 2 and 8: Reproducible hardcopy on archival quality, 28 lb (105 GSM), acid-free, bond paper.

B. Operation and Maintenance Data:

1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:
 - a. Emergency Generator
 - b. Automatic Transfer Switches
 - c. Switchboard and breakers
2. Include the following information:
 - a. Manufacturer's operating specifications.
 - b. User's guides for software and hardware.
 - c. Schedule of maintenance material items recommended to be stored at the Project site.
 - d. Detailed instructions covering operation under both normal and abnormal conditions.
 - e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
 - f. List of load-current and overload-relay heaters with related motor nameplate data.
 - g. List of lamp types and photoelectric relays used on the Project, with ANSI and manufacturers' codes.
 - h. Manufacturer's instructions for setting field-adjustable components.
 - i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
 - j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
 - k. Exterior pole inspection and repair procedures.

C. Software and Firmware Operational Documentation: Provide software and firmware operational documentation in Facility EPM Binders, including the following:

1. Software operating and upgrade manuals.
2. Names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.
6. For lighting controls, include the following:
 - a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
 - b. Operation of adjustable zone controls.

D. Software:

1. Program Software Backup: Provide username and password for approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
2. Provide to Owner upgrades and unrestricted licenses for Government use for installed and backup software, including operating systems and programming tools required for operation and maintenance.

PART 2 - PRODUCTS

2.1 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

- A. Substitution requests for electrical equipment will be entertained under the following conditions:
1. Substitution requests may be submitted for consideration prior to the Electrical Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with the Project performance requirements while significantly increasing value for Owner throughout life of facility.
 2. Substitution requests may be submitted for consideration concurrently with submission of power system study reports when those reports indicate that substitution is necessary for safety of maintenance personnel and facility occupants.
 3. Contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

2.2 FACILITY ELECTRICAL MAINTENANCE PROGRAM (EMP) BINDERS

- A. Description: Set of binders containing operation and maintenance data for facility's electrical equipment that was compiled during analysis of installed electrical Work for Facility EMP development.
- B. Applicable Standards:
1. Regulatory Requirements: Comply with requirements in NFPA 70B.
 2. General Characteristics:
 - a. Volume 1 - Introduction:

- 1) Summarize how Facility EMP analysis was performed, how data were collected, and how volumes are organized.
 - 2) Describe Facility EMP and provide recommended policies and procedures for implementing the program and keeping it current.
 - 3) Provide place for Owner to identify contact information for employees responsible for implementing and maintaining Facility EMP.
- b. Volume 2 - Facility Safety, Hazards Awareness, and Emergency Procedures:
- 1) Include training requirements for employees and contractors.
 - 2) Include list of known facility hazards impacting IT&R activities.
 - 3) Include approval and permitting procedures for IT&R activities.
 - 4) Include incident emergency response procedures.
 - 5) Include emergency shutdown procedures.
 - 6) Include electrical disaster recovery procedures.
 - 7) Include procedures for investigating the following incidents:
 - a) Electrical safety incidents.
 - b) Equipment malfunctions.
 - c) Unintended operations or alarms.
 - d) Operation of protective devices.
- c. Volume 3 - Operating Procedures for Electrical Equipment and Controls: (Refer to specific subsections for detailed requirements)
- 1) Include a summary schedule of all required equipment inspection, maintenance, and testing.
 - 2) Emergency Generators.
 - 3) Automatic transfer switches
 - 4) Switchboards and Panelboards
 - 5) Lighting control system
 - 6) Battery backed up emergency lighting
- d. Volume 4 - Facility Diagrams and Schedules:
- 1) Include single-line diagrams.
 - 2) Include grounding and bonding diagrams.
 - 3) Include essential wiring diagrams.
 - 4) Include system automation diagrams (SCADA, BMS, lighting, HVAC, etc.).
 - 5) Include records of switchgear, switchboard, and panelboard schedules.
 - 6) Include time-current curves for overcurrent protective devices.
 - 7) Include list of load-current and overload-relay heaters with related motor nameplate data.
- e. Volume 5 - Inventory of Facility Equipment Using Electrical Power:
- 1) Include simplified floor plans showing equipment locations.
 - 2) Identify critical equipment (electrical or otherwise).
 - 3) Include identifying designations and nameplate data.

- 4) Include warranty and maintenance contract information.
- f. Volume 6 - Inventory of Facility Tools, Supplies, and Personnel Protective Equipment:
 - 1) Include schedules of maintenance material items recommended to be stored at facility.
 - 2) Include list of lamp types and photoelectric relays used in facility with ANSI and manufacturers' codes.
 - 3) Include calibration and servicing data for each item.
- g. Volume 7 - Inspection, Testing, and Repair (IT&R) Plan:
 - 1) Include tables showing frequency of activities for each item.
 - 2) Include annual schedule with activities mapped to specific days of the year.
 - 3) Include exterior pole inspection and repair procedures.
- h. Volume 10 - Spare Parts List:
 - 1) Include list of all parts required to perform IT&R procedures.
 - 2) Identify quantities of which parts are recommended to be stored on-site.
 - 3) Include source contact information and budget cost for each item.
- i. Volume 11 - Construction Project Closeout Record Documentation:
 - 1) Include records of power system studies and photometric studies.
 - 2) Include records of risk assessment studies.
 - 3) Include records of electrical system startup and commissioning activities.
 - 4) Include records of baseline inspections and tests.
 - 5) Include records of baseline infrared photographs with normal light photographs showing the location, direction, angle, and conditions necessary for reproducing each infrared photograph.
 - 6) Include records of baseline settings for adjustable equipment and devices.

PART 3 - EXECUTION

3.1 DEVELOPMENT OF FACILITY ELECTRICAL MAINTENANCE PROGRAM (EMP)

- A. Facility EMP must be developed by qualified EMP specialist.
- B. Conduct Facility EMP analysis in accordance with NFPA 70B requirements.
 1. Renovation Projects:
 - a. Facility diagrams must include connected existing equipment for entire facility where known. Areas of uncertainty should be clearly indicated.
 - b. Obtain copies of existing operation and maintenance data and existing Facility EMP information from Owner.
 - c. Facility EMP analysis should identify existing equipment that does not have available operation and maintenance data, and should explain Owner's risks because this equipment is not included in Facility EMP.

- d. Data for existing equipment outside scope of the Project may be inserted in Facility EMP Binders without analysis.
 - e. Data for existing equipment impacted by scope of the Project should be analyzed and documented similar to the Project's new equipment data as much as possible.
- C. Compile operation and maintenance data from Facility EMP analysis and submit **[updated]** Facility EMP Binders.

3.2 INSTALLATION OF ELECTRICAL WORK

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of electrical Work on the Project. Consult Architect for resolution of conflicting requirements.

3.3 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:
 - a. How to implement Facility EMP.
 - b. Generator testing and maintenance procedures.
 - c. Automatic transfer switch testing and maintenance procedures.
 - d. Lighting control system operation, maintenance, and troubleshooting procedures.
 - 2. Provide video recordings of training sessions to Owner.

END OF SECTION 260010

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermoplastic-insulated wire.
2. Thermoset-insulated wire.
3. Nonmetallic underground conduit with conductors.
4. Metallic sheathed cable.
5. Photovoltaic single-conductor cable.
6. Nonmetallic jacketed cable.
7. Connectors and splices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35 000 V.
6. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
7. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
9. Section 260533.13 "Conduits for Electrical Systems" specifies installation of raceways referenced by this Section.
10. Section 260536 "Cable Trays for Electrical Systems" specifies cable tray installation referenced by this Section.
11. Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling" specifies installation of sleeves and sleeve seals referenced by this Section.
12. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.

1.2 DEFINITIONS

- A. NICET: National Institute for Certification in Engineering Technologies; a division of the National Society of Professional Engineers (NSPE).

1.3 ACTION SUBMITTALS

- A. Product Schedule: Indicate type, use, location, and termination locations.
- B. Product Data: For each type of product.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Field reports for infrared scanning.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, to conduct tests of complex equipment, to analyze test and equipment data, to plan a job, and to lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; to evaluate tests, test equipment, test results, and power system performance; to recommend actions to maintain or improve system performance; and to lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III] [IV] certification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 THERMOPLASTIC-INSULATED WIRE

- A. Description: Thermoplastic-insulated wire for use in accordance with Article 310 of NFPA 70.
- B. UL ZLGR - Type THHN Insulated Wire:
 - 1.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 3. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
 4. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- C. UL ZLGR - Type THHW Insulated Wire **<Insert drawing designation>**:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 75 deg C
 - d. Conductor Material: Copper
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
 3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.

- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

D. UL ZLGR - Type THW Insulated Wire:

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
- 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 75 deg C
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
- 3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

E. UL ZLGR - Type THW-2 Insulated Wire

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
- 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.

- c. Insulation Temperature Rating: 90 deg C.
- d. Conductor Material: Copper.
- e. Conductor Size: As indicated on the Drawings.

1) Minimum Conductor Size: 12 AWG.

3. Other Available Features Required by the Project:

- a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- f. Marked "VW-1," indicating compliance with special vertical flame test.
- g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

F. UL ZLGR - Type THWN Insulated Wire :

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.

2. Standard Features:

- a. Referenced Standard: Article 310 of NFPA 70.
- b. Insulation Voltage Rating: 600 V.
- c. Insulation Temperature Rating: 75 deg C.
- d. Conductor Material: Copper.
- e. Conductor Size: As indicated on the Drawings.

1) Minimum Conductor Size: 12 AWG.

3. Other Available Features Required by the Project:

- a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

G. UL ZLGR - Type THWN-2 Insulated Wire :

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.]
 - 1) Minimum Conductor Size 12 AWG.
3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

H. UL ZLGR - Type TW Insulated Wire

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 60 deg C.
 - d. Conductor Material: Copper
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size 12 AWG.
3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.

- b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
- c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
- d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
- e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- g. Marked "VW-1," indicating compliance with special vertical flame test.
- h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

I. UL ZLGR - Type FEP Insulated Wire :

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.
- 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Covering: None.
 - c. Insulation Voltage Rating: 600 V.
 - d. Insulation Temperature Rating: 90 deg C for dry and damp locations.
 - e. Conductor Material: Copper.
 - f. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
- 3. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

J. UL ZLGR - Type FEPB Insulated Wire :

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.

- 1) Thermoplastic Fluoropolymer Wire: Also investigated in accordance with UL 83A.
 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Covering: Glass or other suitable braid material.
 - c. Insulation Voltage Rating: 600 V.
 - d. Insulation Temperature Rating: 200 deg C for dry locations.
 - e. Conductor Material: Copper.
 - f. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size 12 AWG.
 3. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- K. UL ZLGR - Type TBS Insulated Switchboard Wire :
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
 - 1) Thermoplastic and Fibrous Outer Braid: Also investigated in accordance with UL 83B.
 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
 3. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.

- d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
- e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
- f. Marked "VW-1," indicating compliance with special vertical flame test.
- g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

2.3 THERMOSET-INSULATED WIRE

- A. Description: Thermoset-insulated wire for use in accordance with Article 310 of NFPA 70.
- B. UL ZKST - Type RHH Insulated Wire :
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
 - 2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
 - 3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.
- C. UL ZKST - Type RHW Insulated Wire :

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 75 deg C.
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

D. UL ZKST - Type RHW-2 Insulated Wire :

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.

3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

E. UL ZKST - Type XHHW Insulated Wire :

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C for dry and damp locations].
 - d. Conductor Material: Copper.
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.

- 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

F. UL ZKST - Type XHHW-2 Insulated Wire :

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.
 - d. Conductor Material: Copper [Aluminum] [**Copper-clad aluminum**].
 - e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
3. Other Available Features Required by the Project:
 - a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
 - b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - g. Marked "VW-1," indicating compliance with special vertical flame test.
 - h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

G. UL ZKST - Type SIS Insulated Switchboard and Switchgear Wire

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
2. Standard Features:
 - a. Referenced Standard: Article 310 of NFPA 70.
 - b. Insulation Voltage Rating: 600 V.
 - c. Insulation Temperature Rating: 90 deg C.

- d. Conductor Material: Copper.
- e. Conductor Size: As indicated on the Drawings.
 - 1) Minimum Conductor Size: 12 AWG.
- 3. Other Available Features Required by the Project:
 - a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
 - b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
 - c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
 - d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
 - e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
 - f. Marked "VW-1," indicating compliance with special vertical flame test.
 - g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
 - h. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
 - 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.
 - i. .

2.4 METALLIC SHEATHED CABLE

A. UL PJAZ - Metal-Clad Cable, Type MC :

- 1. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Metal-Clad Cable: UL CCN PJAZ, including UL 1569.
- 3. Standard Features:
 - a. Referenced Standard: Article 330 of NFPA 70.
 - b. Circuits: Single circuit with color coded conductors..
 - c. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors
 - d. Ground Conductor: Insulated
 - e. Conductor Insulation:
 - 1) Type TFN/THHN/THWN-2. Comply with UL 83.
 - 2) Type XHHW-2. Comply with UL 44.
 - f. Armor: Steel, interlocked.
 - g. Jacket: PVC applied over armor.
- 4. Other Available Features Required by the Project:

- a. Marked "MC-HL," indicating compliance with UL 2225 for use in hazardous (classified) locations.
- B. UL PPKV and FHJR - Fire-Resistant Mineral-Insulated Metal-Sheathed Cable, Type MI, for Use in Electrical Circuit Integrity Systems
 - 1. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Mineral-Insulated Metal-Sheathed Cable: UL CCN PPKV, including UL Subject 504.
 - b. Circuit Integrity: UL CCN FHJR, including UL 2196.
 - 3. Standard Features:
 - a. Referenced Standard: Article 332 of NFPA 70.
 - b. Fire-Resistance Rating: 2 h.
 - c. Conductors: Copper, complying with ASTM B3 for bare annealed copper.
 - d. Insulation: Compressed magnesium oxide.
 - e. Sheath: Copper
- C. UL QPOR - Power and Control Tray Cable, Type TC :
 - 1. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Power and Control Tray Cable: UL CCN QPOR, including UL 1277.
 - 3. Standard Features:
 - a. Comply with NEMA WC 57/ICEA S-73-532 for Type TC cables used for control, thermocouple extension, and instrumentation.
 - b. Comply with NEMA WC 70/ICEA S-95-658 for Type TC cables used for power distribution.
 - c. Conductors: Copper.
 - d. Ground Conductor: Insulated.
 - e. Conductor Insulation: Type XHHW-2. Comply with UL 44.
 - 4. Other Available Features Required by the Project:
 - a. Marked "TC-ER," indicating that cable is designed for use with ASDs, 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.
 - 1) Marked "TC-ER-JP," indicating that cable is also suitable for pulling through structural members in accordance with Article 336.10(9) of NFPA 70.
 - 2) Marked "TC-ER-HL," indicating that cable is also suitable for use in hazardous (classified) environments.

- b. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
- c. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
- 1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

2.5 CONNECTORS AND SPLICES

A. UL PJOX - Armored and Metal-Clad Cable Fittings :

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Type AC and Type MC Cable Connectors: UL CCN PJOX, including UL 514B.
- 2. Standard Features: For steel and aluminum sheathed cables, designed to connect conductors specified in this Section.

B. UL PPYT - Mineral-Insulated Metallic-Sheathed Cable Fittings :

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Type MI Cable Fittings: UL CCN PPYT, including UL 514B.
- 2. Standard Features: For copper sheathed cables, designed to connect conductors specified in this Section.

C. UL ZMVV - Wire Connectors and Soldering Lugs :

- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Wire Connectors and Soldering Lugs: UL CCN ZMVV, including UL 486A-486B or UL 486C.
- 2. Standard Features:
 - a. One piece, seamless, designed to terminate conductors specified in this Section.
 - b. Material: Bronze.
 - c. Type: Two hole with standard barrels.
 - d. Termination: Crimp.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 - 2. Copper for feeders smaller than No. 4 AWG; copper, aluminum, or copper-clad aluminum for feeders No. 4 AWG and larger. Conductors must be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
 - 1. Material: Copper.
 - a. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 - b. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.
- C. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway]
- B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: .
- E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.
- F. Exposed Branch Circuits, Including in Crawlspace: 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.
- I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.
- J. Branch Circuits in Cable Tray, Only for limited applications where specifically allowed by Architect/Engineer: Metal-clad cable, Type MC or Tray Cable, type TC as directed by Engineer.
- K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Temporary Electric Power Work: NECA NEIS 200.
 - 5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 6. Work in Confined Spaces: NFPA 350.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Installation of Type AC and Type MC Cables: NECA NEIS 120.
 - 9. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
 - 2. Complete raceway installation between conductor and cable termination points prior to pulling conductors and cables.
 - 3. 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.
 - 4. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
 - 5. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
 - 6. Provide support for cables.
 - 7. Complete cable tray systems installation prior to installing conductors and cables.
 - 8. Connections:
 - a. Tighten electrical connectors and terminals in accordance with 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.
 - 9. Wiring at Outlets: Install conductor at each outlet, with at least 12 inch (300 mm) of slack.
- D. Interfaces with Other Work:
 - 1. Identification:
 - a. Identify and color-code conductors and cables.
 - b. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

2. Sleeves and Sleeve Seals: Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.
3. Firestopping: Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.4 FIELD QUALITY CONTROL

- A. Administrant for Electrical Power Tests and Inspections:
 1. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
- B. Acceptance Testing Preparation:
- C. Field tests and inspections must be witnessed by Architect..
- D. Tests and Inspections:
 1. Perform manufacturer's recommended tests and inspections.
 2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 3. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors.:
 4. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection in accordance with the single-line diagram.
 - b. Test bolted connections for high resistance using one or more 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.
- E. Nonconforming Work:
 1. Wire or cable assembly will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.5 MAINTENANCE

- A. Infrared Scanning of Splices: Two months after Substantial Completion, perform infrared scan of splices, joints, and connections in conductors 3 AWG and larger. Remove covers so splices, joints, and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison. Correct deficiencies determined during the scan.
 - 1. Follow-On Infrared Scanning: Perform follow-up infrared scan of splices at 11 months after Substantial Completion.
 - 2. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
 - 3. Field Reports for Infrared Scanning: Prepare certified report that identifies cables splices checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. RS-232 cable.
3. RS-485 cable.
4. Control cable.
5. Control-circuit conductors.
6. Fire-alarm wire and cable.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 271500 "Communications Copper Horizontal Cabling" for requirements for Data and Category 5/6/7 balanced twisted pair cable.
4. Section 284600 "Fire Detection and Alarm" for detailed fire alarm system cable requirements.
5. Section 260943.23 "Relay-Based Lighting Controls Systems" for lighting control system cabling requirements.
6. Section 263213.13 "Diesel Engine-Driven Generators" for detailed generator control system cabling requirements.

1.2 ACTION SUBMITTALS

A. Control-Voltage Cable subsystem color schedule

B. Product Data:

1. Backboards.
2. .
3. RS-232 cable.
4. RS-485 cable.
5. Control cable.
6. Control-circuit conductors.
7. Fire-alarm wire and cable.

1.3 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CABLE COLOR SCHEDULE

- A. Provide a complete schedule of cable outer sheath colors for all independent low voltage control systems within the building, including but not limited to:
 - 1. Fire alarm system
 - 2. Lighting Control system
 - 3. Generator and emergency system
 - 4. Communications
 - 5. Security and access control
 - 6. Mechanical/BAS control
 - 7. Electrical energy metering
- B. Provide a unique cable jacket color for each subsystem, complying with owner requirements, relevant specification requirements, and local codes.

2.2 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. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - 1. Flame Travel Distance: 60 inch (1520 mm) or less.
 - 2. Peak Optical Smoke Density: 0.5 or less.
 - 3. Average Optical Smoke Density: 0.15 or less.
- C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 BACKBOARDS

- A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inch (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."
- B. Painting: Paint plywood on all sides and edges with flat latex paint. Comply with requirements in Section 099123 "Interior Painting." Stencil "FR PLYWOOD BACKING" with 3/4" high lettering with red spray-applied paint on a visible corner of the painted plywood. Spray paint shall be compatible with base paint and not weather or flake off.

2.4 RS-232 CABLE

- A. PVC-Jacketed, TIA 232-F:
 - 1. Three No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Polypropylene insulation.
 - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 - 4. PVC jacket.
 - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. NFPA 70 Type: Type CM.
 - 7. Flame Resistance: Comply with UL 1581.
- B. Plenum-Type, TIA 232-F:
 - 1. ThreeNo. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. PE insulation.
 - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. Flame Resistance: Comply with NFPA 262.

2.5 RS-485 CABLE

- A. Standard Cable: NFPA 70, Type CMG.
 - 1. Paired, one pair, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1685.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - 2. Fluorinated ethylene propylene insulation.
 - 3. Unshielded.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Flame Resistance: NFPA 262.

2.6 CONTROL CABLE

- A. Paired Cable: NFPA 70, Type CMG.
 - 1. Multi-pair, twisted, No. 16 AWG, stranded 19x29tinned-copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1685.
- B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.7 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway , Type TC, complying with UL 1277 in raceway.
- B. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 where installed in raceway power-limited cable, where concealed in building finishes .
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.
- D. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.
 1. Smoke control signaling and control circuits.

2.8 FIRE-ALARM WIRE AND CABLE

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
 1. 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 two-hour rating.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
 1. Control-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 2. Low-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor[**with outer jacket**] with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.9 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test twisted pair cables according to TIA-568-C.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Test cables on receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceway selection and installation requirements for conduits as supplemented or modified in this Section.
- B. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems" for raceway selection and installation requirements for wireways as supplemented or modified in this Section.
- C. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for raceway selection and installation requirements for boxes as supplemented or modified in this Section.
 - 1. Outlet boxes must be no smaller than 2 inch (50 mm) wide, 3 inch (75 mm) high, and 2-1/2 inch (64 mm) deep.
 - 2. Outlet boxes for cables must be no smaller than 4 inch (102 mm) square by 2-1/8 inch (53 mm) deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
 - 3. Flexible metal conduit must not be used.
- D. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- E. Install manufactured conduit sweeps and long-radius elbows if possible.
- F. Raceway Installation in Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard if entering the room from overhead.
 - 4. Extend conduits **3 inch (75 mm)** 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.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inch (760 mm) and not more than 6 inch (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. 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." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist balanced twisted pair cables more than 1/2 inch (12 mm) at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inch (200 mm) above ceilings by cable supports not more than 30 inch (760 mm) apart.
3. Cable must not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

- F. 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. Below each feed point, neatly coil a minimum of 72 inch (1830 mm) of cable in a coil not less than 12 inch (305 mm) in diameter.
- G. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded copper voice and data communications 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 must be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inch (127 mm).
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inch (305 mm).
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inch (600 mm).
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment must be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inch (64 mm).
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inch (150 mm).
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inch (305 mm).
 4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures must be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inch (75 mm).
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inch (150 mm).
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inch (1200 mm).
 6. Separation between Communications Cables and LED Drivers: A minimum of 5 inch (127 mm).

3.4 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 CONTROL-CIRCUIT CONDUCTORS

- A. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits; No 14 AWG
 - 2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG
 - 3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG

3.6 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" Chapter.

3.7 GROUNDING

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.
- C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.9 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm 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 direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

- a. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "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.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connectors.
7. Grounding and bonding busbars.
8. Signal reference grids.
9. Grounding (earthing) electrodes.
10. Grounding electrode enclosures.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 264113 "Lightning Protection for Structures" specifies bonding of lightning protection grounding electrodes to facility grounding electrodes.
5. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

- B. Shop Drawings: Prepare and submit the following:
 - 1. Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:
 - a. Grounding electrode access enclosures.
 - b. Grounding electrodes.
 - c. Grounding arrangements and connections for separately derived systems.
- C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
 - 1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:
 - a. Plans showing locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:
 - 1) Grounding electrode access enclosures.
 - 2) Grounding electrodes.
 - 3) Grounding arrangements and connections for separately derived systems.
 - 4) **<Insert items>**.
 - b. Instructions for periodic testing and inspection of grounding features at test wells based on **NFPA 70B**
 - 1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems, evaluate tests, test equipment, test results, and power system performance, recommend actions to maintain or improve system performance, and lead multi-team projects.

- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician [III] [IV] certification.

1.6 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

- A. Soil Resistivity: Grounding (earthing) Work on the Project must account for soil resistivity conditions specified in Section 018116 "Facility Environmental Requirements."
- B. Electrical and ICT Equipment Grounding (Earthing): Do not exceed 25 Ω resistance to ground (earth).
 - 1. Contact Architect for resolution if 25 Ω specified resistance to ground (earth) is not attained after complying with prescriptive requirements in Article 250 of NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. <Insert additional performance requirements for the Project>.

2.2 GROUNDING AND BONDING CONDUCTORS

- A. Equipment Grounding Conductor:
 - 1. Standard Features: 600 V, THHN/THWN-2, copperwire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. ASTM - Bare Copper Grounding and Bonding Conductor:
 - 1. Standard Features: Complying with one or more of the following:
 - a. Soft or Annealed Copper Wire: ASTM B3.
 - b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
 - c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
 - d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.
 - 2. Sustainable Design Features:
 - a. At least 10% recycled copper content.
- C. UL KDSH - Protector Grounding Conductor:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
2. Standard Features:
 - a. Conductors intended to be used for grounding primary protector or metallic members of cable sheath in accordance with Chapters 7 and 8 of NFPA 70.
 - b. Color: green.

2.3 GROUNDING AND BONDING CLAMPS

- A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.
- B. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 3. Standard Features:
 - a. Two pieces with **[zinc-plated]** **[stainless steel]** bolts.
 - b. Clamp Material: Brass
 - c. Listed for outdoor use.
- C. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp:
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 3. Standard Features:
 - a. Clamp Material: Brass
 - b. Listed for outdoor use.
- D. UL KDER and KDSH - Strap-Type Pipe and Rod Grounding and Bonding Clamp

1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 3. Standard Features:
 - a. Clamp Material Tinned copper.
 - b. Listed for outdoor use.
- E. UL KDER - Beam Grounding and Bonding Clamp **<Insert drawing designation>**:
1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 3. Standard Features: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.
- F. UL KDER - Exothermically Welded Connection
1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 3. Standard Features: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING AND BONDING BUSHINGS

- A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.
- B. UL KDER - Bonding Bushing :
1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

3. Standard Features: Threaded bushing with insulated throat.

C. UL KDER - Grounding Bushing

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

3. Standard Features: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.5 GROUNDING AND BONDING HUBS

A. UL KDER - Grounding and Bonding Hub

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

3. Standard Features: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.6 GROUNDING AND BONDING CONNECTORS

A. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

- b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

3. Standard Features: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.

B. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
3. Standard Features: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.
 - a. Tinned copper, C and H shaped.

2.7 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

- A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.
- B. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 2. Standard Features: Zinc-alloy one-piece construction; six terminating points; gangable.
- C. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding Connector:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 2. Standard Features: **[Zinc-alloy] [Copper]** body and polycarbonate cover; four terminating points.

2.8 GROUNDING AND BONDING BUSBARS

- A. Description: Miscellaneous grounding and bonding devices that serve as common connection for multiple grounding and bonding conductors.
- B. UL KDER - Equipment Room Grounding and Bonding Busbar **<Insert drawing designation>**:
 1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
3. Standard Features:
 - a. Bus: Rectangular bar of annealed copper.
 - b. Mounting Stand-Off Insulators: Lexan or PVC.
 - 1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.
4. Other Available Features Required by the Project:
 - a. Dimensions: [**1/4 by 4 inch (6.3 by 100 mm)**] <Insert dimensions> in cross section; length as indicated on the Drawings.
 - b. Predrilled Hole Pattern: [**Complying with BICSI N3 and TIA-607**] [**9/32 inch (7.14 mm) holes spaced 1-1/8 inch (28 mm) apart**] [Suitable for installing specified grounding and bonding connectors].
 - c. Mounting Hardware: Stand-off brackets that provide [**2 inch (50 mm)**] [**4 inch (100 mm)**] <Insert dimension> clearance to access rear of bus. Brackets and bolts must be stainless steel.

C. UL KDER - Rack and Cabinet Bonding Busbar

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
3. Standard Features:
 - a. Bus: Rectangular bar of hard-drawn solid copper.
 - b. Mounting Dimensions: Confirm rack mounting width with Owner ITS Consultant.
 - c. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.
 - d. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.

2.9 GROUNDING (EARTHING) ELECTRODES

A. UL KDER - Rod Electrode <Insert drawing designation>:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

3. Standard Features: **Copper-clad** steel ; 3/4 inch by 10 ft (19 mm by 3 m).
4. Sustainable Design Features:

B. UL KDER - Plate Electrode

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
3. Standard Features: 1/4 inch (6 mm) thick, hot-dip galvanized.

2.10 GROUNDING ELECTRODE ENCLOSURES

- A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.
- B. Grounding Electrode Access Well Enclosure:
 1. Source Limitations: Obtain products from single manufacturer.
 2. Standard Features:
 - a. Well Material: **Concrete**.
 - b. Cover Material: **Concrete**
 - c. Cover Strength: **Tier 22 or better rated**
 3. Other Available Features Required by the Project:
 - a. Rectangular:
 - 1) Nominal Width: 12 inch (300 mm).
 - 2) Nominal Length: 12 inch (300 mm).
 - 3) Nominal Height: 12 inch (300 mm)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine facility's 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 electrical system.
- B. Inspect test results of grounding system measured at point of electrical service equipment connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

- D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS

- A. Grounding and Bonding Conductors:
 - 1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG > and larger unless otherwise indicated.
 - 2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
 - 3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
 - 5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Underground Grounding Conductors: Install bare copper conductor, 2/0 AWG minimum.
- B. Grounding and Bonding Connectors:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Welded connectors.
 - 4. Connections to Structural Steel: Welded connectors.
- C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.

3.3 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

- A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.4 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR TOWERS AND ANTENNAS

- A. Special Techniques:
 - 1. Ring Electrode: Buried at least 30 inch (760 mm) below grade and at least 24 inch (610 mm) from base of tower or mounting.
 - 2. Bond each tower base and metallic frame of dish to ring electrode, buried at least 18 inch (460 mm) below grade.
 - 3. Bond ring electrode and antenna bonding conductors to equipment room PBB or SBB, buried at least 30 inch (760 mm) below grade.
 - 4. Bond metal fences located within 6 ft (1.8 m) of towers and antennas to ring electrode, buried at least 18 inch (460 mm) below grade.
 - 5. Special Requirements for Roof-Mounted Towers:
 - a. Roof Ring: Meet requirements for ring electrode except conductors must comply with NFPA 780.

- b. Bond tower base footings steel, SBB in equipment room, and antenna support guys to roof ring.
- c. Connect roof ring to perimeter conductors of lightning protection system.
- 6. Special Requirements for Waveguides and Coaxial Cable:
 - a. Bond cable shields at point of entry into building to nearest SBB and to cable entrance plate, using 2 AWG bonding conductors.
 - b. Bond coaxial cable surge arrester to ring electrode or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

3.5 INSTALLATION OF GROUNDING AND BONDING

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 5. Communications Work: BICSI N1.
 - 6. Work in ITE Rooms: NFPA 75.
 - 7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 8. Work in Confined Spaces: NFPA 350.
 - 9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 10. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
 - 11. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 - 1. Grounding and Bonding Conductors:
 - a. 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. Underground Grounding Conductors:
 - 1) Bury at least 30 inch (750 mm) below grade.
 - 2) Duct-Bank Grounding Conductor: Bury 12 inch (300 mm) above duct bank when indicated as part of duct-bank installation.
 - 2. Grounding and Bonding Connectors: 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.
 - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 - b. Make connections with clean, bare metal at points of contact.

- c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 - f. 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 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 disconnect-type connection is required, use bolted clamp.
 - g. 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 bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where 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 bolted connector.
 - 3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 - h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
 - i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft (18 m) apart.
3. Grounding and Bonding Busbars:
- a. Install busbar horizontally, on insulated spacers 2 inch (50 mm) minimum from wall, 6 inch (150 mm) above finished floor unless otherwise indicated.
 - b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.
4. Electrodes:
- a. Ground Rods: Drive rods until tops are 2 inch (50 mm) 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 below-grade connections.
 - b. For grounding electrode system, install at least **[three]** **<Insert number>** rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to 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 must be at least 12 inch (300 mm) deep, with cover.
 - 1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor. Refer to Site Plan for specific location(s).
 - d. Concrete-Encased Electrode (Ufer Ground):
 - 1) Fabricate in accordance with NFPA 70; use minimum of 20 ft (6 m)]of bare copper conductor not smaller than 4 AWG
 - a) If concrete foundation is less than 20 ft (6 m) **<Insert dimension>** long, coil excess conductor within base of foundation.
 - b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
 - 2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft (6.0 m) long. If reinforcing is in multiple pieces, connect together by exothermic welding to create required length.
5. Grounding at Service:
- a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.
6. Grounding Separately Derived Systems:
- a. Permanent Generators: Install grounding electrode(s) at location of permanent generators having switched neutral connections. Electrode must be connected to equipment grounding conductor and to frame of generator.
7. Grounding Underground Distribution System Components:
- a. Duct-Bank Grounding Conductor: Bury 12 inch (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 driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch (100 mm) will extend

above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch (50 mm) above to 6 inch (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 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.
- e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than 6 inch (150 mm) from foundation.

8. Equipment Grounding and Bonding:

- a. Install insulated equipment grounding conductors with feeders and branch circuits.
- b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1) Feeders and branch circuits.
 - 2) Lighting circuits.
 - 3) Receptacle circuits.
 - 4) Single-phase motor and appliance branch circuits.
 - 5) Three-phase motor and appliance branch circuits.
 - 6) Flexible raceway runs.
 - 7) Armored and metal-clad cable runs.
- c. 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.
- d. Water Heater,: Install separate insulated equipment grounding conductor to each electric water heater. Bond conductor to heater units, piping, connected equipment, and components.
- e. Poles Supporting Outdoor Lighting Fixtures: Bond insulated equipment grounding conductor to equipment grounding terminal inside pole base.
- f. Metallic Fences: Comply with requirements of IEEE C2.
 - 1) Grounding Conductor: Barecopper, not less than **8 AWG**
 - 2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
 - 3) Barbed Wire: Strands must be bonded to grounding conductor.

9. Fence Grounding:

- a. Grounding Method: At each grounding location, drive grounding rod vertically until top is 6 inch (150 mm) below finished grade. Connect rod to fence with 6 AWG conductor. Connect conductor to each fence component at grounding location.

- b. Fences greater than 100 ft (30 m) of Buildings, Structures, Walkways, and Roadways: Ground fence at maximum intervals of 1500 ft (450 m) **<Insert lesser distance if grounding resistance is high>**.
- c. Fences within 100 ft (30 m) of Buildings, Structures, Walkways, and Roadways: Ground fence at maximum intervals of 750 ft (225 m).
 - 1) Gates and Other Fence Openings: Ground fence on each side of opening.
 - a) Bond metal gates to gate posts by connecting bonding jumper between gate post and gate frame.
 - b) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use 2 AWG wire and bury it at least 18 inch (460 mm) below finished grade.
- d. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of power line crossing and at maximum distance of 150 ft (45 m) on each side of crossing.
- e. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground fence and bond fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.6 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

- A. Administrant for Electrical Power Tests and Inspections:
 - 1. Owner will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections with assistance of factory-authorized service representative.
- B. Field tests and inspections must be witnessed by Architect/Engineer and authorities having jurisdiction
- C. 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 calibrated torque wrench in accordance with manufacturer's published instructions.
 - 3. Test completed grounding system at each location where 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 conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by 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 in accordance with IEEE Std 81.
 - c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
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 record of tests and observations. Include 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.
- D. Nonconforming Work:
- 1. Grounding system will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective components and retest.
- E. Collect, assemble, and submit test and inspection reports.
- 1. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω
 - b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω
 - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω
 - d. Power Distribution Units or Panelboards Serving Electronic Equipment: [1 Ω] 3 Ω
 - e. Pad-Mounted Equipment: 5 Ω

3.7 PROTECTION

- A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support systems.
2. Mounting, anchoring, and attachment components.
3. Installation of fabricated metal supports.
4. Installation of concrete bases.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 033000 "Cast-in-Place Concrete" specifies concrete materials, reinforcement, and placement requirements referenced by this Section.
5. Section 055000 "Metal Fabrications" specifies site-fabricated metal supports referenced by this Section.
6. Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" specify cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal referenced by this Section.
7. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration controls, seismic restraints, and wind restraints referenced by this Section.

1.2 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals: Engage qualified structural professional engineer to design hangers and supports for electrical systems.

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 Submittals: 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. Welding certificates.

1.5 REGULATORY AGENCY APPROVALS

- A. Delegated design submittals and shop drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. [Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.] [Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]

1.6 QUALIFICATIONS

- A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind controls, equipment hangers and supports, and concrete foundations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Prepare design calculations in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 018123 "Facility Seismic and Wind Criteria."
- 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 Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT SYSTEMS

- A. Steel Slotted Support Systems
 - 1. Standard Features: Preformed steel channels and angles with minimum 13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one surface.
 - a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
 - b. Material for Channel, Fittings, and Accessories: Galvanized steel.
 - c. Channel Width: Selected for applicable load criteria.
 - d. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Aluminum Slotted Support Systems :
 - 1. Standard Features: Extruded-aluminum channels and angles with minimum 13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one surface.
 - a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Material: 6063-T5 aluminum alloy.
 - c. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 - d. Channel Width: [Selected for applicable load criteria] [1-5/8 inch (41.25 mm)] [1-1/4 inch (31.75 mm)] [13/16 inch (20.64 mm)] <Insert dimension>.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Conduit and Cable Support Devices:

1. Standard Features: **[Steel]** **[Steel and malleable-iron]** **[Stainless steel]** **[Glass-fiber-resin]** hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit:
1. Standard Features: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints:
1. Standard Features: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

2.3 MOUNTING, ANCHORING, AND ATTACHMENT COMPONENTS

- A. Powder-Actuated Fasteners
1. Standard Features: 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.
- B. Mechanical-Expansion Anchors
1. Standard Features: 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.
- C. Concrete Inserts:
1. Standard Features: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
- D. Clamps for Attachment to Steel Structural Elements:
1. Standard Features: MSS SP-58 units are suitable for attached structural element.
- E. Through Bolts:
1. Standard Features: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).
- F. Toggle Bolts:
1. Standard Features: Stainless steel springhead type.
- G. Hanger Rods:
1. Standard Features: Threaded steel.

PART 3 - EXECUTION

3.1 SELECTION OF HANGERS AND SUPPORTS

- A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch (6 mm) in diameter.
- B. 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]**.
- C. 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 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Hot Work: NFPA 51B.
 - 3. Work in Confined Spaces: NFPA 350.
 - 4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 5. Installation of Steel Conduit: NECA NEIS 101.
 - 6. Installation of Aluminum Conduit: NECA NEIS 102.
 - 7. Installation of Metal Cable Tray Systems: NECA NEIS 105.
 - 8. Installation of Nonmetallic Cable Tray Systems: NECA NEIS 111.
 - 9. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Raceway Support Methods: In addition to methods described in NECA NEIS 1, **[EMT]** **[IMC]** **[and]** **[ERMC]** may be supported by openings through structure members, in accordance with NFPA 70.
 - 2. 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 must be weight of supported components plus 200 lb (90 kg).
 - 3. 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:
 - a. To Wood: Fasten with lag screws or through bolts.

- b. To New Concrete: Bolt to concrete inserts.
 - c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - d. To Existing Concrete: Expansion anchor fasteners.
 - e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inch (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch (100 mm) thick.
 - f. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - g. To Light Steel: Sheet metal screws.
 - h. 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.
4. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
- D. Interfaces with Other Work:
- 1. Provide vibration and seismic controls with hangers and supports.
 - 2. Touchup Finishes:
 - a. 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. 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.
 - 3. Installation of Fabricated Metal Supports:
 - a. Provide 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. Submit welding certificates.
 - 4. Installation of Concrete Bases:
 - a. Provide concrete bases of dimensions indicated, but not less than 4 inch (100 mm) 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 (20.7 MPa), 28-day compressive-strength 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.

END OF SECTION 260529

SECTION 260533.13 - CONDUITS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT duct raceways and elbows.
2. Type HDPE and Type EPEC duct raceways and fittings.
3. Type ERMC duct raceways, elbows, couplings, and nipples.
4. Type FMC duct raceways.
5. Type FMT duct raceways.
6. Type IMC duct raceways.
7. Type LFMC duct raceways.
8. Type LFNC duct raceways.
9. Type PVC duct raceways and fittings.
10. Type RTRC duct raceways and fittings.
11. Fittings for conduit, tubing, and cable.
12. Joint compounds.
13. Solvent cements.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies firestopping referenced by this Section.
5. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
6. Section 260529 "Hangers and Supports for Electrical Systems" specifies conduit hangers and supports referenced by this Section.
7. Section 260543 "Underground Ducts and Raceways for Electrical Systems" specifies exterior duct banks, manholes, and underground utility construction.
8. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels.
9. Section 270528 "Pathways for Communications Systems"[and **Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for installation of conduits for communications cabling.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-A: Aluminum electrical metallic tubing.
3. EMT-S: Steel electrical metallic tubing.
4. EMT-SS: Stainless steel electrical metallic tubing.
5. ENT: Electrical nonmetallic tubing.
6. EPEC: Electrical HDPE underground conduit (thin wall).
7. EPEC-A: Type A electrical HDPE underground conduit.
8. EPEC-B: Type B electrical HDPE underground conduit.
9. ERMC: Electrical rigid metal conduit.
10. ERMC-A: Aluminum electrical rigid metal conduit.
11. ERMC-S: Steel electrical rigid metal conduit.
12. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
13. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
14. ERMC-SS: Stainless steel electrical rigid metal conduit.
15. FMC: Flexible metal conduit.
16. FMC-A: Aluminum flexible metal conduit.
17. FMC-S: Steel flexible metal conduit.
18. FMT: Steel flexible metallic tubing.
19. FNMC: Flexible nonmetallic conduit. See "LFNC."
20. HDPE: HDPE underground conduit (thick wall).
21. HDPE-40: Schedule 40 HDPE underground conduit.
22. HDPE-80: Schedule 80 HDPE underground conduit.
23. IMC: Steel electrical intermediate metal conduit.
24. LFMC: Liquidtight flexible metal conduit.
25. LFMC-A: Aluminum liquidtight flexible metal conduit.
26. LFMC-S: Steel liquidtight flexible metal conduit.
27. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
28. LFNC: Liquidtight flexible nonmetallic conduit.
29. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
30. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
31. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
32. PVC: Rigid PVC conduit.
33. PVC-40: Schedule 40 rigid PVC conduit.
34. PVC-80: Schedule 80 rigid PVC Conduit.
35. PVC-A: Type A rigid PVC concrete-encased conduit.
36. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
37. RGS: See ERMC-S-G.
38. RMC: See ERMC.
39. RTRC: Reinforced thermosetting resin conduit.
40. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
41. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
42. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
43. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
44. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

B. Definitions:

1. Conduit: A structure containing one or more duct raceways.
2. Direct Buried: Installed underground without encasement in concrete or other protective material.
3. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.

4. Duct Raceway: A single enclosed raceway for conductors or cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Raceway Color Schedule
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician III certification.
- D. ERMC-S-PVC Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by ERMC-S-PVC manufacturer prior to starting installation.
- E. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site communications testing supervisor must have BICSI Technician (TECH) certification and documented training, and be experienced with testing communications equipment in accordance with BICSI testing standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Colored Raceway Requirements: Colored conduit is required in all interior and covered locations, except where specifically noted to be painted to match adjacent finishes. The following conduit types are required to be colored:
 - 1. EMT and all applicable variations
 - 2. FMC, for raceway lengths over 3'
 - 3. LFMC, for raceway lengths over 3'

2.2 RACEWAY COLOR SCHEDULE

- A. Colored raceways for shall be steel conduit complying with requirements below, with secondary organic color coating applied.
- B. Provide a complete schedule of specialty-colored raceways, coordinated with Cable Color Schedule required by 26 05 23.
 - 1. Fire Alarm Systems: Red coated conduit
 - 2. Generator Control, signaling, and communications: Orange coated conduit
 - 3. Mechanical Controls: Blue coated conduit
 - 4. Communications low voltage systems: white coated conduit
- C. Provide a framed copy of raceway color schedule alongside Electrical One-Line Diagram in Main Electrical room.

2.3 TYPE EMT DUCT RACEWAYS AND ELBOWS

- A. UL FJMX - Aluminum Electrical Metal Tubing (EMT-A) and Elbows:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FJMX; including UL 797A.
 - 2. Standard Features:
 - a. Material: Aluminum.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

- B. UL FJMX - Stainless Steel Electrical Metal Tubing (EMT-SS) and Elbows:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FJMX; including UL 797A.
 - 2. Standard Features:
 - a. Material: Stainless steel.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- C. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FJMX; including UL 797.
 - 2. Standard Features:
 - a. Material: Steel.
 - b. Exterior Coating: Zinc.
 - c. Interior Coating: Zinc with organic top coating.
 - d. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.4 TYPE HDPE AND TYPE EPEC DUCT RACEWAYS AND FITTINGS

- A. UL EAZX - Schedule 40 Electrical HDPE Underground Conduit (HDPE-40):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
 - 2. Standard Features:
 - a. Dimensional Specifications: Schedule 40.
 - 3. Other Available Features Required by the Project:

- a. Minimum Trade Size] Metric designator 21 (trade size 3/4).
- B. UL EAZX - Schedule 80 Electrical HDPE Underground Conduit (HDPE-80):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
 - 2. Standard Features:
 - a. Dimensional Specifications: Schedule 80.
 - 3. Other Available Features Required by the Project:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- C. UL EAZX - Type A Electrical HDPE Underground Conduit (EPEC-A):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
 - 2. Standard Features:
 - a. Dimensional Specifications: Type A.
 - 3. Other Available Features Required by the Project:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- D. UL EAZX - Type B Electrical HDPE Underground Conduit (EPEC-B):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EAZX; including UL 651A.
 - 2. Standard Features:
 - a. Dimensional Specifications: Type B.
 - 3. Other Available Features Required by the Project:
 - a. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)].**

2.5 TYPE ERM C DUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

- A. UL DYWV - Aluminum Electrical Rigid Metal Conduit (ERM C-A), Elbows, Couplings, and Nipples:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYWV; including UL 6A.
 - 2. Standard Features:
 - a. Material: Aluminum.
 - b. Protective Coating: Provide protective coating for use in concrete.
 - c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- B. UL DYWV - Stainless Steel Electrical Rigid Metal Conduit (ERM C-SS), Elbows, Couplings, and Nipples:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYWV; including UL 6A.
 - 2. Standard Features:
 - a. Material: Stainless steel.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- C. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERM C-S-G), Elbows, Couplings, and Nipples:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYIX; including UL 6.
 - 2. Standard Features:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc with organic top coating .

- c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- D. UL DYIX - PVC-Coated-Steel Electrical Rigid Metal Conduit (ERMC-S-PVC), Elbows, Couplings, and Nipples:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYIX; including UL 6.
 - 2. Standard Features:
 - a. Exterior Coating: PVC complying with NEMA RN 1.
 - b. Interior Coating: **[Zinc with organic top coating] [Zinc] [Organic coating]**.
 - c. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)]**.
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
 - b. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

2.6 TYPE FMC DUCT RACEWAYS

- A. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXUZ; including UL 1.
 - 2. Standard Features:
 - a. Material: Steel.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- B. UL DXUZ - Aluminum Flexible Metal Conduit (FMC-A):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. UL CCN DXUZ; including UL 1.
2. Standard Features:
 - a. Material: Aluminum.
 - b. Minimum Trade Size Metric designator 21 (trade size 3/4).
3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.7 TYPE FMT DUCT RACEWAYS

- A. UL ILJW - Steel Flexible Metallic Tubing (FMT):
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ILJW; including UL Subject 1652.
 2. Standard Features:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.8 TYPE IMC DUCT RACEWAYS

- A. UL DYBY - Steel Intermediate Metal Conduit (IMC):
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DYBY; including UL 1242.
 2. Standard Features:
 - a. Exterior Coating: **[Zinc] [Alternative corrosion-resistant coating]**.
 - b. Interior Coating: **[Zinc with organic top coating] [Zinc] [Organic coating]**.
 - c. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)]**.
 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.9 TYPE LFMC DUCT RACEWAYS

- A. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXHR; including UL 360.
 2. Standard Features:
 - a. Material: Steel.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- B. UL DXHR - Stainless Steel Liquidtight Flexible Metal Conduit (LFMC-SS):
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXHR; including UL 360.
 2. Standard Features:
 - a. Material: Stainless steel.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)]**.
 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.10 TYPE LFNC DUCT RACEWAYS

- A. UL DXOQ - Layered (Type A) Liquidtight Flexible Nonmetallic Conduit (LFNC-A):
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXOQ; including UL 1660.
 2. Standard Features:
 - a. Type A conduit with smooth seamless inner core and cover bonded together with one or more reinforcement layers between core and cover.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)]**.

- c. Markings: 70 deg C oil resistant, **Sunlight resistant**[Outdoor] [Direct burial] **[Complies with flame test in cable trays]**.
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.
- B. UL DXOQ - Integral (Type B) Liquidtight Flexible Nonmetallic Conduit (LFNC-B):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXOQ; including UL 1660.
 - 2. Standard Features:
 - a. Type B conduit with smooth inner surface with integral reinforcement within conduit wall.
 - b. Minimum Trade Size: **[Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)]**.
 - c. Markings: **[80 deg C dry] [90 deg C dry] [105 deg C dry] [70 deg C oil resistant] [Sunlight resistant] [Outdoor] [Direct burial] [Complies with flame test in cable trays]**.
- C. UL DXOQ - Corrugated (Type C) Liquidtight Flexible Nonmetallic Conduit (LFNC-C):
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXOQ; including UL 1660.
 - 2. Standard Features:
 - a. Type C conduit with corrugated internal and external surfaces without integral reinforcement within conduit wall.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - c. Markings: 90 deg C dry
 - 3. Other Available Features Required by the Project:
 - a. Colors: As indicated on the Drawings.

2.11 TYPE PVC DUCT RACEWAYS AND FITTINGS

- A. UL DZYR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYR; including UL 651.

2. Standard Features:
 - a. Dimensional Specifications: Schedule 40.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- B. UL DZYZ - Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZ; including UL 651.
 2. Standard Features:
 - a. Dimensional Specifications: Schedule 80.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- C. UL DZYZ - Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZ; including UL 651.
 2. Standard Features:
 - a. Dimensional Specifications: Type A.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 3. Sustainable Design Features:
- D. UL DZYZ - Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DZYZ; including UL 651.
 2. Standard Features:
 - a. Dimensional Specifications: Type EB.
 - b. Minimum Trade Size: Metric designator 78 (trade size 3)

2.12 FITTINGS FOR CONDUIT, TUBING, AND CABLE

- A. UL EBMB - Duct Fittings for Hazardous (Classified) Locations:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN EBMB; including UL 1203.
- B. UL DWTT - Fittings for Type ERMCM, Type IMC, Type PVC, Type HDPE, Type EPEC, and Type RTRC Duct Raceways:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DWTT; including UL 514B.
 2. Standard Features:
 - a. Material: Steel
 - b. Coupling Method: Indoor: Compression coupling, Outdoor or in damp locations: Raintight compression coupling with distinctive color gland nut
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
- C. UL FKAV - Fittings for Type EMT Duct Raceways:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FKAV; including UL 514B.
 2. Standard Features:
 - a. Material: Steel.
 - b. Coupling Method: Indoor: Compression coupling, Outdoor or in damp locations: Raintight compression coupling with distinctive color gland nut
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
- D. UL ILNR - Fittings for Type FMC Duct Raceways:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ILNR; including UL 514B.
- E. UL DXAS - Fittings for Type LFMC Raceways:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN DXAS; including UL 514B.

2.13 JOINT COMPOUNDS

- A. UL FOIZ - Electrically Conductive Corrosion-Resistant Compound for Threaded Conduit:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN FOIZ; including UL Subject 2419.

2.14 SOLVENT CEMENTS

- A. UL VBEW - Solvent Cements for Nonmetallic Duct Raceways and Fittings:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Solvent Cements: UL CCN VBEW; including UL 340.
 - b. Solvent Cement Compatibility with PVC Conduit Fittings: UL CCN DWTT; including UL 514B. Follow solvent manufacturer's published instructions.
 - c. Solvent Cement Compatibility with Rigid PVC Conduit: UL CCN DZYR; including UL 651. Follow solvent manufacturer's published instructions.
 - d. Solvent Cement Compatibility with Rigid EPEC and HDPE Underground Conduit: UL CCN EAZX; including UL 651A. Follow solvent manufacturer's published instructions.

PART 3 - EXECUTION

3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturer's published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.
- B. Special Instructions Regarding HDPE Conduits: Although Article 353 of NFPA 70 permits use of HDPE conduits where encased in concrete aboveground, UL CCN EAZX listing requirements state that HDPE[**and EPEC**] underground conduits are intended only for use where direct buried with or without being encased in concrete. Specified Type HDPE[**and Type EPEC**] underground conduits are not permitted to be used aboveground on the Project.
- C. Outdoors:
 - 1. Exposed and Subject to Severe Physical Damage: ERM C.
 - 2. Exposed and Subject to Physical Damage: An
 - 3. Exposed and Not Subject to Physical Damage: Corrosion-resistant EMT].
 - 4. Concealed Aboveground: EMT]
 - 5. Direct Buried: PVC-40.
 - 6. Concrete Encased Not in Trench: PVC-80.
 - 7. Concrete Encased in Trench: PVC-40.

8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- D. Indoors:
1. Exposed and Subject to Physical Damage: IMC.
 2. Exposed and Not Subject to Physical Damage: EMT.
 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 4. Damp or Wet Locations: Corrosion-resistant EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC -B].
- E. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
1. ERMIC and IMC: Provide threaded-type fittings unless otherwise indicated.

3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 5. Communications Work: BICSI N1.
 6. Life Safety and Means of Egress Work: NFPA 101.
 7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 8. Work in Confined Spaces: NFPA 350.
 9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 10. Type EMT-A: Article 358 of NFPA 70 and NECA NEIS 102.
 11. Type EMT-SS: Article 358 of NFPA 70 and NECA NEIS 101.
 12. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
 13. Type ENT: Article 362 of NFPA 70 and NECA NEIS 102.
 14. Type HDPE and Type EPEC: Article 353 of NFPA 70 and NECA NEIS 111.
 15. Type ERMIC-A: Article 344 of NFPA 70 and NECA NEIS 102.
 16. Type ERMIC-SS: Article 344 of NFPA 70 and NECA NEIS 101.
 17. Type ERMIC-S: Article 344 of NFPA 70 and NECA NEIS 101.
 18. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
 19. Type FMC-A: Article 348 of NFPA 70 and NECA NEIS 102.
 20. Type FMT: Article 360 of NFPA 70 and NECA NEIS 101.
 21. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.
 22. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
 23. Type LFNC: Article 342 of NFPA 70 and NECA NEIS 111.
 24. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
 25. Type RTRC: Article 355 of NFPA 70 and NECA NEIS 111.
 26. Expansion Fittings: NEMA FB 2.40.
 27. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:

1. General Requirements for Installation of Duct Raceways:
 - a. Complete duct raceway installation before starting conductor installation.
 - b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft (0.6 m) above finished floor.
 - c. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch (300 mm) of changes in direction.
 - d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
 - e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
 - f. Support conduit within 12 inch (300 mm) of enclosures to which attached.
 - g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.
 - h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct 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 duct raceway enters a building or structure.
 - 3) Conduit extending from interior to exterior of building.
 - 4) Conduit extending into pressurized duct raceway and equipment.
 - 5) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - 6) Where otherwise required by NFPA 70.
 - i. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.
 - j. Do not install conduits within 2 inch (50 mm) of the bottom side of a metal deck roof.
 - k. Keep duct raceways at least 6 inch (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.
 - l. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
 - m. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb (90 kg) tensile strength. Leave at least 12 inch (300 mm) of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.
 - n. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
 - 1) Termination fittings with shoulders do not require two locknuts.

- o. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. **[Install insulated throat metal grounding bushings on service conduits].**
- 2. Types EMT-A, ERMCA, and FMC-A: Do not install aluminum duct raceways or fittings in contact with concrete or earth.
- 3. Types ERMCA and IMC:
 - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
- 4. Type ERMCA-S-PVC:
 - a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
 - b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMCA-S-PVC elbows in direct-burial applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMCA-S-PVC duct raceway.
 - c. Coat field-cut threads on PVC-coated duct raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.
- 5. Types FMC, LFMC, and LFNC:
 - a. Provide a maximum of 36 inch (915 mm) of flexible conduit for **[recessed and semirecessed luminaires]**, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
- 6. Types PVC, HDPE, and EPEC:
 - a. Do not install Type PVC, Type HDPE, or Type EPEC conduit where ambient temperature exceeds 122 deg F (50 deg C). Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
 - b. Comply with manufacturer's published instructions for solvent welding and fittings.
 - c. Join joints with solvent cement in accordance with manufacturer's published instructions and allowed to cure before handling. Joints to be bent, pushed, or pulled must set for minimum 24 h after joining.
- 7. =
- 8. Duct Raceways Embedded in Slabs:
 - a. Duct raceways embedded in slabs are generally not allowed. Where other installation methods are impractical, they may be allowed with express written permission from Structural Engineer, Architect, and Electrical Engineer on a case by case basis.

- b. Arrange duct raceways to cross building expansion joints with expansion fittings at right angles to the joint.
 - c. Arrange duct raceways to ensure that each is surrounded by minimum of [1 inch (25 mm)] [2 inch (50 mm)] <Insert dimension> of concrete without voids.
 - d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
- 9. Stub-ups to Above Recessed Ceilings:
 - a. Provide EMT, IMC, or ERM for duct raceways.
 - b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- 10. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:
 - a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG. Install insulated throat metal grounding bushings on service conduits.
- 11. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.
 - a. ERM-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - b. EMT: Provide compression, fittings. Comply with NEMA FB 2.10.
 - c. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.
- 12. Expansion-Joint Fittings:
 - a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F (17 deg C) and that have straight-run length that exceeds 25 ft (7.6 m). Install in runs of aboveground ERM and EMT conduit that are located where environmental temperature change may exceed 100 deg F (55 deg C) and that have straight-run length that exceeds 100 ft (30 m).
 - b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
 - 1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) <Insert temperature> temperature change.
 - 2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C)
 - 3) Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - c. 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 0.00078 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.
 - d. Install expansion fittings at locations where conduits cross building or structure expansion joints.
 - e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific

location at time of installation. Install conduit supports to allow for expansion movement.

13. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.
14. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.
 - a. Provide warning signs.

D. Interfaces with Other Work:

1. Firestop penetrations of fire-rated floor and wall assemblies.
2. Provide conduit hangers and supports.

3.3 FIELD QUALITY CONTROL OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Administrant for Electrical Power Tests and Inspections:

1. Administer and perform tests and inspections

B. Administrant for Communications Tests and Inspections:

1. Administer and perform tests and inspections

C. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch (300 mm) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
3. Conduit Placement:
 - a. Verify that center-line location and offsets are in accordance with the Drawings.
 - b. Verify that hangers and supports for conduits are attached to structure as directed by qualified structural engineer.
 - c. Verify that nuts on bolts or hanger rods are secure.
 - d. Verify that space between raceways and cored holes are filled with non-shrinking grout or other approved material indicated on the Drawings and the Specifications.
 - e. Verify that expansion devices are installed at locations indicated on the Drawings and the Specifications.
 - f. Verify that ends are cut square to provide flush-butting surfaces when spliced and inside edges are free of burrs that could impede installation of cables.
 - g. Verify minimum separation of utilities, or that approved mechanical protection has been provided to surrounding conduit(s) where minimum separation cannot be achieved.
4. Document all changes on Record Drawings.

D. Nonconforming Work:

1. Conduit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

- E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

- A. Verify that bentonite or other drilling fluids are contained and removed, and site is restored to its original or improved condition.

3.5 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 260533.13

SECTION 260533.16 - BOXES AND COVERS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Nonmetallic outlet boxes, device boxes, rings, and covers.
3. Junction boxes and pull boxes.
4. Cover plates for device boxes.
5. Hoods for outlet boxes.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.
8. Section 270528 "Pathways for Communications Systems"[and **Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
- B. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:
1. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.

2. Concrete Box: A box intended for use in poured concrete.
 3. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
 4. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
 5. Cover Plate: A cover designed for protecting wiring devices installed in flush-mounted device boxes while permitting their safe operation; also called a faceplate or wallplate.
 6. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
 7. Device Box: A box with provisions for mounting a wiring device directly to the box.
 8. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
 9. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
 10. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
 11. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
 12. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
 13. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
 14. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
 15. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
 16. Raised-Floor Box: A floor box intended for use in raised floors.
 17. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
 18. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
 19. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
 20. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
 21. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.
- C. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
- D. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.

1.3 ACTION SUBMITTALS

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

- B. Samples: For each type of product requiring samples for source quality control.
- C. Shop Drawings: Prepare and submit the following:
 - 1. Shop Drawings for Floor Boxes: Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness **[at location]** where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician I: Possessing active NICET I&TFAS Level I certification. Able to perform periodic inspections and tests of basic fire-alarm systems and prepare related records and reports.
- D. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician II: Possessing active NICET I&TFAS Level II certification. Able to plan, perform, and coordinate periodic inspections and tests of complex fire-alarm systems (including one or more of suppression interfaces, networked control units, smoke control interfaces, air sampling systems, multi-zone voice evacuation systems, or high-rise applications) and prepare related records and reports.
- E. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician IV certification.
- F. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have **[BICSI Technician (TECH)] <Insert certification program>** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI] <Insert code enforced by authorities having jurisdiction>** testing standards.
- G. Security Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site security testing supervisor must have ASIS certification and documented training and experience with testing security equipment in accordance with ASIS testing standards.
- H. Fire-Alarm Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site fire-alarm testing supervisor must possess active NICET I&TFAS Technician II certification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

- A. Source Quality Control:
 1. Samples:
 - a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
- B. UL QCIT - Metallic Outlet Boxes and Covers:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 2. Standard Features:
 - a. Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
 - b. Material: Sheet steel.
 - c. Sheet Metal Depth: Minimum 2 inch (50 mm).

- d. Cast-Metal Depth: Minimum 2.4 inch (60.3 mm).
- 3. Other Available Features Required by the Project:
 - a. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 50 lb (23 kg).
 - b. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb (32 kg).
- C. UL QCIT - Metallic Conduit Bodies:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 - 2. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
- D. UL QCIT - Metallic Device Boxes:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 - 2. Standard Features:
 - a. Box with provisions for mounting wiring device directly to box.
 - b. Material: Sheet steel.
 - c. Sheet Metal Depth: minimum 2 inch (50 mm).
 - d. Cast-Metal Depth: minimum 2.4 inch (60.3 mm).
- E. UL QCIT - Metallic Extension Rings:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 - 2. Standard Features: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
- F. UL QCIT - Metallic Floor Boxes and Floor Box Covers:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.

2. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
- G. UL QCIT - Metallic Raised-Floor Boxes and Floor Box Covers:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 2. Standard Features: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.
- H. UL QCIT - Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:
 1. **[Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory]**in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 2. Standard Features: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.
- I. UL QCIT - Metallic Concrete Boxes and Covers:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT; including UL 514A.
 2. Standard Features: Box intended for use in poured concrete.

2.3 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

- A. Source Quality Control:
 1. Samples:
 - a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
 - d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

- B. UL QCMZ - Nonmetallic Outlet Boxes and Covers:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
 - 2. Standard Features: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
- C. UL QCMZ - Nonmetallic Conduit Bodies:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
 - 2. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
- D. UL QCMZ - Nonmetallic Floor Boxes and Floor Box Covers:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
 - 2. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
- E. UL QCMZ - Nonmetallic Raised-Floor Boxes and Floor Box Covers:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
 - 2. Standard Features: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.
- F. UL QCMZ - Nonmetallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.

2. Standard Features: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

G. UL QCMZ - Nonmetallic Floor Nozzles:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
2. Standard Features: Enclosure intended primarily as housing for receptacle, provided with means, such as collar, for surface-mounting on floor, which may or may not include stem to support it above floor level, and is sealed against the entrance of scrub water at floor level.

H. UL QCMZ - Nonmetallic Concrete Boxes and Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCMZ; including UL 514C.
2. Standard Features: Box intended for use in poured concrete.

2.4 JUNCTION BOXES AND PULL BOXES

A. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: Type 1.

B. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:

- a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: Type 1.
- C. UL BGUZ - Indoor Polymeric Junction and Pull Boxes:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
 - 2. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: Type 1
- D. UL BGUZ - Outdoor Sheet Metal Junction and Pull Boxes:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
 - 2. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: Type 3X.
- E. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.
 - 2. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: Type 4X.
- F. UL BGUZ - Outdoor Polymeric Junction and Pull Boxes:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN BGUZ; including UL 50 and UL 50E.

2. Standard Features:
 - a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - b. Degree of Protection: Type 4X .

2.5 COVER PLATES FOR DEVICE BOXES

- A. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 2. Standard Features:
 - a. Cover plate-Securing Screws: Metal with head color to match cover plate finish.
 - b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - c. Cover Plate Material: Steel with white baked enamel, suitable for field painting. As indicated on architectural Drawings.
 - d.
- B. UL QCIT or QCMZ - Nonmetallic Cover Plates for Device Boxes:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 2. Standard Features:
 - a. Cover Plate-Securing Screws: Metal with head color to match cover plate finish.
 - b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - c. Cover Plate Material: As indicated on architectural Drawings.
 - d. Color: As indicated on Drawings.
- C. UL QCIT or QCMZ - Illuminating Cover Plates for Device Boxes:
 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 2. Standard Features:
 - a. Cover Plate-Securing Screws: Metal with head color to match cover plate finish.

- b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - c. Cover Plate Material: As indicated on Drawings].
 - d. ColorAs indicated on Drawings.
- D. UL QCIT or QCMZ - Extra-Duty, While-in-Use Hoods for Outlet Boxes:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 - b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
 - 2. Standard Features:
 - a. Mounts to box using fasteners different from wiring device.
 - b. Marked "Extra-Duty" in accordance with UL 514D.
 - c. Provides clear, weatherproof, "while-in-use" cover.
 - d. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

3.1 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
 - 1. Outdoors:
 - a. Type 4 unless otherwise indicated.
 - b. Locations Exposed to Hosedown: Type 4X .
 - c. Locations Subject to Potential Flooding: Type 6P.
 - d. Locations in-Ground or Exposed to Corrosive Agents: [Type 4X] [Type 6P] [Type 3RX].
 - 2. Indoors:
 - a. Type 1 unless otherwise indicated.
 - b. Damp or Dusty Locations: Type 4
 - c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
 - d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12K.
 - e. Locations Exposed to Hosedown: Type 4.
 - f. Locations Exposed to Brief Submersion: Type 6P.
 - g. Locations Exposed to Prolonged Submersion: Type 6P.

- h. Locations Exposed to Corrosive Agents: [Type 4X.
 - i. Locations Exposed to Spraying Oil or Coolants: Type 13.
- C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
 - 1. [Provide cast-metal boxes.Boxes with knockouts or unprotected openings are prohibited.
 - 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.2 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 - 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 5. Communications Work: BICSI N1.
 - 6. Life Safety and Means of Egress Work: NFPA 101.
 - 7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 8. Work in Confined Spaces: NFPA 350.
 - 9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 10. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
 - 11. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
 - 2. 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.
 - 3. 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, whether installed indoors or outdoors.
 - 4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
 - 5. Locate boxes so that cover or plate will not span different building finishes.
 - 6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
 - 7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
 - 8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
 - 9. Set metal floor boxes level and flush with finished floor surface.
 - 10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
 - 11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.

12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
 - a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
 - b. Provide gaskets for cover plates and covers.

D. Interfaces with Other Work:

1. Identification: Provide labels for boxes and associated electrical equipment. Refer to section 26 05 53 for detailed requirements.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.3 FIELD QUALITY CONTROL OF BOXES AND COVERS

A. Administrant for Electrical Power Tests and Inspections:

1. Owner will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Administrant for Communications Tests and Inspections:

1. Owner will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Administrant for Security Tests and Inspections:

1. Owner will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.

3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections with assistance of factory-authorized service representative.
- D. Administrant for Fire-Alarm Tests and Inspections:
1. **Owner** will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 4. Administer and perform tests and inspections with assistance of factory-authorized service representative.
- E. Acceptance Testing Preparation:
- F. Field tests and inspections must be witnessed by **Architect** and authorities having jurisdiction
- G. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
 2. Perform tests and inspections recommended by standards listed in "Reference Standards for Installation" Paragraph.
- H. Nonconforming Work:
1. Boxes and covers will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- I. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

- A. Remove construction dust and debris from boxes before installing cover plates, covers, and hoods.

3.5 PROTECTION

- A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260533.16

SECTION 260533.23 - SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Surface metal raceways and fittings.
2. Surface nonmetallic raceways.
3. Strut-type channel raceways and fittings.
4. Wireways and auxiliary gutters.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260553 "Identification for Electrical Systems" specifies warning signs referenced by this Section.
6. Section 270528 "Pathways for Communications Systems"[and **Section 271100 "Communications Equipment Room Fittings"**] specifies additional requirements for identification of communications equipment and cabling.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each type of product requiring samples for source quality control.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.

1.4 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.

- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician IV certification.
- D. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have **[BICSI Technician (TECH** certification and documented training, and be experienced with testing communications equipment in accordance with **[BICSI] <Insert code enforced by authorities having jurisdiction>** testing standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 SURFACE METAL RACEWAYS AND FITTINGS

- A. Source Quality Control:
 - 1. Samples:
 - a. Surface Metallic Raceway Nonmetallic Cover Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch (300 mm)long.
- B. UL RJBT - Surface Metal Raceways and Fittings with Metal Covers:
 - a. UL CCN RJBT; including UL 5.
 - 2. Standard Features:
 - a. **Galvanized steel**base with snap-on covers.
 - b. Manufacturer's standard enamel finish in color selected by Architect
 - c. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
 - d.

2.3 WIREWAYS AND AUXILIARY GUTTERS

- A. Source Quality Control:
 - 1. Samples:
 - a. Nonmetallic Wireway and Auxiliary Gutter Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch (300 mm) long.
- B. UL ZOYX - Metal Wireways and Auxiliary Gutters:
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ZOYX; including UL 870.
 - 2. Standard Features:
 - a. 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.
 - b. Finish: Manufacturer's standard enamel finish.
 - c. Wireway Covers: Screw-cover type unless otherwise indicated.
 - 3. Other Available Features Required by the Project:
 - a. Degree of Protection: Type 1 unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Communications Work: BICSI N1.
 - 5. Work in Confined Spaces: NFPA 350.
 - 6. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 7. Auxiliary Gutters: Article 366 of NFPA 70.
 - 8. Surface Metal Raceway: Article 386 of NFPA 70.
 - 9. Surface Nonmetallic Raceway: Article 388 of NFPA 70.
 - 10. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:

1. Install surface raceways only where indicated on Drawings.
2. Install surface raceway with a minimum 2 inch (50 mm) radius control at bend points.
3. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's published instructions. Tape and glue are unacceptable support methods.

D. Interfaces with Other Work:

1. Identification: Provide labels for surface raceways and associated electrical equipment, in accordance with 26 05 53.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.

3.2 FIELD QUALITY CONTROL OF SURFACE RACEWAYS

- A. Adminstrant for Electrical Power Tests and Inspections:
 1. Administer and perform tests and inspections
- B. Tests and Inspections:
 1. Perform manufacturer's recommended tests and inspections.
 2. Perform tests and inspections recommended by standards listed in "Reference Standards for Installation" Paragraph.
- C. Nonconforming Work:
 1. Boxes and covers will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.3 CLEANING

- A. Remove construction dust and debris from surface raceways before installing covers.

3.4 PROTECTION

- A. After installation, protect surface raceways from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260533.23

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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Pourable sealants.
7. Foam sealants.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Steel Wall Sleeves:

1. General Characteristics: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. Cast-Iron Wall Sleeves:

1. General Characteristics: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

C. PVC Pipe Sleeves:

1. General Characteristics: ASTM D1785, Schedule 40.

- D. PVC Molded Sleeves:
 - 1. General Characteristics: With nailing flange for attaching to wooden forms.
- E. PE or PP Molded Sleeves:
 - 1. General Characteristics: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Round, Galvanized-Steel, Sheet Metal Sleeves:
 - 1. General Characteristics: Galvanized-steel sheet; thickness not less than 0.0239 inch (0.6 mm); round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 RECTANGULAR SLEEVES

- A. Rectangular, Galvanized-Steel, Sheet Metal Sleeves:
 - 1. General Characteristics:
 - a. Material: Galvanized sheet steel.
 - b. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inch (1270 mm) and with no side larger than 16 inch (400 mm), thickness must be 0.052 inch (1.3 mm).
 - 2) For sleeve cross-section rectangle perimeter not less than 50 inch (1270 mm) or with one or more sides larger than 16 inch (400 mm), thickness must be 0.138 inch (3.5 mm).

2.3 SLEEVE-SEAL SYSTEMS

- A. General Characteristics: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.
- B. Options:
 - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Stainless steel.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

2.5 GROUT

- A. General Characteristics: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
 - 1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
 - 2. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

2.6 POURABLE SEALANTS

- A.
- B. Performance Criteria:
 - 1. General Characteristics: Single-component, neutral-curing elastomeric sealants of grade indicated below.
 - a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2.7 FOAM SEALANTS

- A.
- B. Performance Criteria:
 - 1. General Characteristics: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.
 - 2. Sustainability Characteristics:

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. 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 space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. 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."
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide 1/4 inch (6.4 mm) annular clear space between sleeve and raceway or cable, unless sleeve-seal system is to be installed or 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 inch (50 mm) above finished floor level. Install sleeves during erection of floors.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for wall assemblies.
- C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch (25 mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- E. Underground, Exterior-Wall and Floor Penetrations:
1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch (25 mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.
 2. Install steel pipe sleeves. Size sleeves to allow for 1 inch (25 mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS

- A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.
- B. Install conduits and cable with no crossings within the sleeve.
- C. Fill opening around conduits and cables with expanding foam without leaving voids.
- D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- 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.

END OF SECTION 260544

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vibration controls.
2. Seismic and wind controls.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.

1.2 DEFINITIONS

- A. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."

1.3 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals: Engage qualified structural professional engineer to design seismic and wind controls.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Prepare and submit catalog cuts, brochures, diagrams and performance data illustrating size, physical appearance, and other characteristics of product.
 - a. Include rated load capacity for each seismic- and wind-restraint device.
 - b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic- and wind-restraint component used.
 - c. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by UL product listing.

- d. Annotate to indicate application of each product submitted and compliance with requirements.
- B. Shop Drawings:
 - 1. Detail fabrication and assembly of equipment bases.
 - 2. 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.
 - 3. Show coordination of seismic and wind bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- C. Delegated Design Submittals:
 - 1. For each seismic-restraint device that is required by this Section or is indicated on the Drawings, submit the following:
 - a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic criteria. Include certification that device is approved by qualified testing laboratory for seismic reinforcement use.
 - c. Seismic Design Calculations: Submit input data and loading calculations.
 - 2. For each wind-restraint device that is required by this Section or is indicated on the Drawings, submit the following:
 - a. Wind Restraint: Select wind restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind criteria. Include certification that device is approved by qualified testing laboratory for reinforcement use.
 - c. Wind Design Calculations: Submit static and dynamic loading calculations.
 - 3. Seismic- and Wind-Restraint Detail Drawings:
 - 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 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 details with wind details required for equipment mounted outdoors.
 - 4. Product Listing, Preapproval, and Evaluation Documentation: By UL, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- D. Field quality-control reports.

1.5 REGULATORY AGENCY APPROVALS

- A. Delegated design submittals and shop drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.

1.6 QUALIFICATIONS

- A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind controls, equipment hangers and supports, and concrete foundations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Prepare design calculations in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 018123 "Facility Seismic and Wind Criteria."
- B. Seismic and Wind Restraint Device Ratings: Devices must be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices must be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: UL product listing.
- C. Consequential Damage: Provide additional seismic and wind restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component will not cause failure of any other essential building component.
- D. Fire/Smoke Resistance: Seismic- and wind-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by qualified testing laboratory in accordance with ASTM E84 or UL 723, and be so labeled.
- E. Component Supports:
 - 1. Load ratings, features, and applications of reinforcement components must be based on testing standards of qualified testing laboratory.

2.2 VIBRATION CONTROLS

- A. Elastomeric Isolation Pads
 - 1. Standard Features:
 - a. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

- b. Size: Factory or field cut to match requirements of supported equipment.
- c. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
- d. Surface Pattern: Smooth, ribbed, or waffle pattern.
- e. Infused nonwoven cotton or synthetic fibers.
- f. Load-bearing metal plates adhered to pads.
- g. Sandwich-Core Material: [**Resilient**] [**and**] [**elastomeric**] <Insert compound>.
 - 1) Surface Pattern: Smooth, ribbed, or waffle pattern.
 - 2) Infused nonwoven cotton or synthetic fibers.

2.3 SEISMIC AND WIND CONTROLS

- A. Restraints - Rigid Type <Insert drawing designation>:
 - 1. Standard Features: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.
- B. Restraints - Cable Type <Insert drawing designation>:
 - 1. Standard Features:
 - a. Seismic- and Wind-Restraint Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.
 - b. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.
- C. Restraint Accessories
 - 1. Standard Features:
 - a. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.
 - b. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
 - 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.
- D. Mechanical Anchor Bolts
 - 1. Standard Features:

- a. 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 for anchor and as tested according to ASTM E488/E488M.
- b. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
- c. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

E. Adhesive Anchor Bolts

1. Standard Features

- a. 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/E488M.
- b. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
- c. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

F. Concrete Inserts

1. Standard Features:

- a. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.
- b. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic and wind 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 SELECTION OF VIBRATION AND SEISMIC CONTROLS

- 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 where indicated or scheduled on the 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 static, wind, and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC AND WIND CONTROLS

- A. Provide seismic and wind control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind Controls Schedule, where indicated on the Drawings, where the Specifications indicate they must be installed on specific equipment and systems, and where required by applicable codes.
 - 1. Install equipment and devices to withstand the effects of earthquake motions and high wind events.
- B. Coordinate 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."
- C. Installation of seismic and wind restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.
- D. Equipment 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 and wind-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Raceway, Cable, Wireway, Cable Tray, and Busway Support 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 and wind-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
 - 3. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 4. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. 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.
- H. 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.
- I. Post-Installed Concrete 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 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. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor will be fastened.
 4. Adhesive-Type Anchor Bolts: 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.
- J. Accommodation of Differential Seismic Motion: 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.

3.4 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by authorities having jurisdiction
- B. Special Structural Tests and Inspections:
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 no fewer than 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. Nonconforming Work:
1. Seismic controls will be considered defective if they do not pass tests and inspections.
 2. Remove and replace malfunctioning units and retest as specified above.
- D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Extruded insulating tubing.
3. Bands.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 284600 "Fire Detection and Alarm"[and **Section 284614 "Single- and Multiple-Station Alarms"**] specifies fire detection and alarm devices referenced in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- 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: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 LABELS

- A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.
- B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- C. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil (0.08 mm) thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
1. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
 2. Marker for Labels:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. UL PGDQ2 - Self-Adhesive Labels: 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. Minimum Nominal Size:
 - a. 1-1/2 by 6 inch (37 by 150 mm) for raceway and conductors.
 - b. 3-1/2 by 5 inch (76 by 127 mm) for equipment.
 - c. As required by authorities having jurisdiction.

2.2 EXTRUDED INSULATING TUBING

- A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN YDPU2 for components; including UL 224.
- B. UL YDPU2 - 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 maximum of 200 deg F (93 deg C).

2.3 BANDS

- A. 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.
- B. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.

2.4 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.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil (0.08 mm) thick by 1 to 2 inch (25 to 50 mm) wide; compounded for outdoor use.
- C. Tape and Stencil: 4 inch (100 mm) wide black stripes on 10 inch (250 mm) centers placed diagonally over orange background and are 12 inch (300 mm) wide. Stop stripes at legends.
- D. Floor Marking Tape: 2 inch (50 mm) wide, 5 mil (0.125 mm) pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
- E. Underground-Line Warning Tape:
 - 1. Tape:
 - a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape must be permanent and may not be damaged by burial operations.
 - c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 - 2. Color and Printing:
 - a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
 - b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW"
 - 3. Reinforced Detectable Line-Warning Tape:
 - a. Reinforced, detectable three-layer laminate, consisting of printed pigmented woven scrim, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright-colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
 - b. Width: 3 inch (75 mm).
 - c. Overall Thickness: 8 mil (0.2 mm).
 - d. Foil Core Thickness: 0.35 mil (8.9 m).
 - e. Weight: 34 lb/1000 sq. ft (16.6 kg/100 sq. m).
 - f. Tensile in accordance with ASTM D882: 300 lbf (1334 N) and 12,500 psi (86.1 MPa).
- F. Concrete Cable Route Markers :
 - 1. Description: Concrete markers visually aid tracing the route of electrical cables. Monument markers are typically installed at grade. Protective cover markers are typically installed above the cables at grade or below grade.
 - 2. Product Characteristics:
 - a. Material: Precast reinforced concrete.
 - b. Marker Type:

- 1) In-Ground Protective Cover (Plank or Slab):
 - a) Nominal Dimensions (Length, Width, Depth): 36 inch (914 mm), 6 inch (150 mm), 2 inch (50 mm)
 - c. Legend: "DANGER – ELECTRICITY"
 - d. Lettering: Approximately 1/8 inch (3 mm) deep, not less than 1 inch (25 mm high, symmetrically spaced; marked on both sides to allow for reversal.
3. Required Product Options:
- G. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height must be 1 inch (25 mm)

2.5 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
 - 1.
- B. Write-on Tags:
 1. Polyester Tags: 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
 2. Marker for Tags:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.6 SIGNS

- A. Baked-Enamel Signs:
 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 2. 1/4 inch (6.4 mm) grommets in corners for mounting.
 3. Nominal Size: 7 by 10 inch (180 by 250 mm).
- B. Laminated Acrylic or Melamine Plastic Signs:
 1. Engraved legend.
 2. Thickness:
 - a. For signs up to 20 sq. inch (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
 - b. For signs larger than 20 sq. inch (129 sq. cm), 1/8 inch (3.2 mm) thick.
 - c. Engraved legend, colored per Electrical Details.
 - d. Punched or drilled for mechanical fasteners with 1/4 inch (6.4 mm) grommets in corners for mounting, or Self-adhesive. Refer to Electrical Details for specific requirements for each sub-type of label.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.
- B. UL ZODZ - 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) in accordance with 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. UL ZODZ - 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) in accordance with 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. UL ZODZ - 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) in accordance with 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.

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 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

- A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:
 - 1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red. Refer to 26 05 33.23 for detailed requirements.

2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft (2.3 m) above finished floor.
- B. Pipe and Conduit Labeling: Comply with ASME A13.1 and IEEE C2.
- C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 1. Color must be factory applied
 2. Colors for 208Y/120 V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 3. Colors for 480Y/277 V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 4. Color for Neutral (Grounded Conductor):
 - a. 120V to neutral: White.
 - b. 277V to Neutral: **Gray**.
 5. Color for Equipment Ground: Green.
 6. Color for Isolated Ground: Green with two or more yellow stripes.
- D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.
- E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.
- F. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. Provide labelling in accordance with Electrical Details. System legends must be as follows:
 1. "EMERGENCY POWER."
 2. "POWER."
 3. "UPS."
- G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- H. Locations of Underground Lines: Underground-line warning tape for power and lighting.
- I. Vaults, Manholes, Handholes, and Pull and Junction Boxes, More Than 1000 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags. Refer to Electrical Details for color, formatting, and content requirements.

- J. Vaults, Manholes, Handholes, and Pull and Junction Boxes, 1000 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify phase and circuit.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft (15 m) maximum intervals in straight runs, and at 25 ft (7.6 m) maximum intervals in congested areas.
 - 2. Identify system voltage, system, and panel with colors per Electrical Details.
- K. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 20 A or 120 V to Ground: Identify with self-adhesive raceway labels.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft (15 m) maximum intervals in straight runs, and at 25 ft (7.6 m) maximum intervals in congested areas.
 - 2. Identify system voltage, system, and panel with color per Electrical Details.
- L. Conductors to Be Extended in Future: Attach write-on tags to conductors and list source.
- M. Cover Plates: Label individual cover plates with self-adhesive labels. Place label at top of cover plate. Label cover plate with the following information, in the order listed:
 - 1. Panelboard designation.
 - 2. Colon or dash.
 - 3. Branch circuit number.
- N. Workspace Indication: Apply tape and stencil to finished surfaces. Show working clearances in direction of access to live parts. Workspace must 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.
- O. Equipment Identification Labels:
 - 1. Black letters on white field.
 - 2. Indoor Equipment: Laminated acrylic or melamine plastic sign.
 - 3. Outdoor Equipment: Laminated acrylic or melamine sign below Stenciled legend 4 inch (100 mm) high.
 - 4. Equipment to Be Labeled:
 - a. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels per the requirements on Electrical Details page.
 - b. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of engraved, laminated acrylic or melamine label.
 - c. Enclosures and electrical cabinets.
 - d. Access doors and panels for concealed electrical items.
 - e. Switchgear.
 - f. Switchboards.
 - g. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
 - h. Substations.
 - i. Emergency system boxes and enclosures.
 - j. Enclosed switches.
 - k. Enclosed circuit breakers.

- l. Enclosed controllers.
- m. Variable-speed controllers.
- n. Power-transfer equipment.
- o. Contactors.
- p. Uninterruptible power supplies.
- q. Battery-inverter units.
- r. Battery racks.
- s. Power-generating units.
- t. Monitoring and control equipment.

P. 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 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:

- 1. Safety Colors: NEMA Z535.1.
- 2. Facility Safety Signs: NEMA Z535.2.
- 3. Safety Symbols: NEMA Z535.3.
- 4. Product Safety Signs and Labels: NEMA Z535.4.
- 5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

C. Electrical Hazard Warnings:

- 1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with NFPA 70E and Section 260573 "Power System Studies" requirements for arc-flash hazard warning labels.
- 2. Raceways and Cables Carrying Circuits at More Than 1000 V:
 - a. Black letters on orange field.
 - b. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- 3. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
- 4. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."
- 5. Refer to Electrical Details for additional information.

D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

- 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.

- E. Operating Instruction Signs: Self-adhesive labels Laminated acrylic or melamine plastic signs.
- F. Emergency Operating Instruction Signs: Baked-enamel warning signs with white legend on red background with minimum 3/8 inch (10 mm) high letters for emergency instructions at equipment used for power transfer .

3.4 SELECTION OF IDENTIFICATION PRODUCTS FOR COMMUNICATIONS, CONTROL, AUXILIARY, AND LIFE SAFETY SYSTEMS

- A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.5 INSTALLATION

- 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. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes typical for electrical equipment environments specified in Section 018116 "Facility Environmental Requirements" and Section 260010 "Supplemental Requirements for Electrical."
- C. 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).
- D. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.
- E. 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.
- F. Install identifying devices before installing acoustical ceilings and similar concealment.
- G. Verify identity of item before installing identification products.
- H. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- I. Apply identification devices to surfaces that require finish after completing finish work.
- J. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.
- L. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.

2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.
- M. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.
- N. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.
- O. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.
- P. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.
- Q. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.
- R. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- S. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- T. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.
- U. Underground Line Warning Tape:
 1. During backfilling of trenches, install continuous underground-line warning tape not less than 12 inch (300 mm) directly above cables or raceways buried 18 inch (450 mm) or more below grade. Use multiple tapes where width of multiple lines installed in common trench or concrete envelope exceeds 16 inch (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.
- V. Metal Tags:
 1. Place in location with high visibility and accessibility.
 2. Secure using cable ties suitable for the application per above requirements.
- W. Nonmetallic Preprinted Tags:
 1. Place in location with high visibility and accessibility.
 2. Secure cable ties suitable for the application per above requirements.
- X. Write-on Tags:
 1. Place in location with high visibility and accessibility.
 2. Secure using cable ties suitable for the application per above requirements.
- Y. Baked-Enamel Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

- Z. Metal-Backed Butyrate Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
- AA. Laminated Acrylic or Melamine Plastic Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

END OF SECTION 260553

SECTION 260573 - POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Short-circuit study.
2. Overcurrent protective device coordination study.
3. Voltage-drop study.
4. Arc-flash hazard study.
5. Digital-twin modeling.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 DEFINITIONS

- A. Digital Twin: The digital representation of a real-world entity, concept, or notion, either physical or perceived.

1.3 ACTION SUBMITTALS

A. Product Data: For power system analysis software to be used for studies.

1. Product Certificates: For power system study software applications, include certificate stating compliance with specified requirements, signed by software manufacturer.

B. Power System Study Reports:

1. Submit reports after approval of system protective devices submittals. Submittals must be in digital form.
2. Submit short-circuit study input data, including completed computer-program input data sheets.
3. Submit coordination study input data, including completed computer-program input data sheets.
 - a. Submit voltage-drop data with coordination study.
4. Submit arc-flash study input data, including completed computer-program input data sheets.
5. 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.

- 6. Submit revised one-line diagram, reflecting field investigation results and results of short-circuit study.
- C. Data files for studies in format compatible with Owner's power system analysis software.
- D. Digital-twin models.

1.4 QUALITY ASSURANCE

- A. Submittals for power system studies must be signed and sealed by qualified electrical professional engineer responsible for their preparation.
- B. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.
- C. Software algorithms must comply with requirements of standards and guides specified in this Section.
- D. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

- A. Standard Features:
 - 1. Power System Analysis:
 - a. Power-systems-analysis software applications must have analytical capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 3002 series standards.
 - b. Computer software application must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.
 - c. Computer software application must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.
 - 2. Analysis Standards:
 - a. Short-Circuit Current Analysis: In accordance with IEEE 3002.3.
 - b. Device Coordination Analysis: In accordance with IEEE 3004.3 and IEEE 3004.5.
 - c. Harmonic Analysis: In accordance with IEEE 3002.8.
 - d. Arc-Flash Hazard Analysis: In accordance with IEEE 1584.
 - 3. Capable of printing arc-flash hazard warnings for equipment on vinyl, weather- and UV-resistant, pressure-sensitive adhesive labels complying with NFPA 70E.

- a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard study:
 - 1) Equipment 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.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Collect and analyze data for power system studies.
 - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Architect's attention.
 - 2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
 - 3. Gather and tabulate required input data to support power system studies. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 3002 series standards as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:
 - a. Product data for the 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.
 - b. Electrical power utility impedance at service.
 - c. Power sources and ties.
 - d. Short-circuit current at each system bus (three phase and line to ground).
 - e. Full-load current of loads.
 - f. Voltage level at each bus.
 - g. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 - h. 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.

- i. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
- j. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
- k. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
- l. Motor horsepower and NEMA MG 1 code letter designation.
- m. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
- n. Derating factors.

3.2 PREPARATION

A. Preparation of Data for Short-Circuit Study:

- 1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Architect's attention.
- 2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
- 3. Prepare one-line diagram of modeled power system, showing the following:
 - a. Protective device designations and ampere ratings.
 - b. Conductor types, sizes, and lengths.
 - c. Transformer kVA and voltage ratings.
 - d. Motor and generator designations and kVA ratings.
 - e. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
 - f. Derating factors and environmental conditions.
 - g. Revisions to electrical equipment required by study.

B. Preparation of Data for Overcurrent Protective Device Coordination Study:

- 1. Prepare data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, indicating 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 condition where available fault current is greater than 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.
 - 2. Examine the Project's 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.
 - 3. 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.
- C. Preparation of Data for Arc-Flash Hazard Study:
- 1. Assemble data from short-circuit study and overcurrent protective device coordination study.
 - 2. 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.

3.3 SHORT-CIRCUIT STUDY

- A. Base study on device characteristics supplied by device manufacturer.
- B. Extent of electrical power system to be studied is indicated on Drawings.
- C. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 5 kA or less.
 - 2. Exclude equipment supplied by single transformer smaller than 75 kVA.
- D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- E. Include 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.
- F. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
- G. Include in report identification of protective device applied outside its capacity.

3.4 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

- A. Base study on device characteristics supplied by device manufacturer. When analysis of full range of device is impractical, limiting scope of analysis from 10 to 100 percent of device range is acceptable.
- B. Begin analysis at service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 5 kA or less.
- C. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- D. Transformer Primary Overcurrent Protective Devices:
 - 1. Device must not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads in accordance with IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings must protect transformers in accordance with IEEE C57.12.00, for fault currents.
- E. Motor Protection:
 - 1. Select protection for low-voltage motors in accordance with IEEE 3004.8 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V in accordance with IEEE 620.
- F. Conductor Protection: Protect cables against damage from fault currents in accordance with ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 3004.7. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- G. Generator Protection: Select protection in accordance with manufacturer's published instructions and IEEE C37.102.
- H. Include 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.
- I. Include coordination of ground-fault protection devices.
- J. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

K. 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. Application of series-rated devices must be recertified, complying with requirements in NFPA 70.
4. Include in report identification of protective device applied outside its capacity.

3.5 VOLTAGE-DROP STUDY

- A. Perform voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:
1. Determine voltage drop based on full-load currents.
 2. Determine voltage drop based on 80 percent of design capacity of load buses.
 3. Prepare voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.6 MOTOR-STARTING STUDY

- A. Perform motor-starting study to analyze transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze effects of motor starting on power system stability.
- B. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 1453, and voltage sags so as not to affect operation of other utilization equipment on system supplying motor.

3.7 ARC-FLASH HAZARD STUDY

- A. Comply with NFPA 70E, including Annex D, for arc-flash hazard study.
- B. Preparatory Studies: Obtain short-circuit study and overcurrent protective device coordination study results prior to starting arc-flash hazard study.
- C. Calculate maximum and minimum contributions of fault-current size.
1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
 3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.
 4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.
- D. Calculate 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.
- F. Calculate limited, restricted, and prohibited approach boundaries for each location.
- G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must account for changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:
 - 1. Fault contribution from induction motors must not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).
- H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:
 - 1. When circuit breaker is in separate enclosure.
 - 2. When line terminals of circuit breaker are separate from 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.

3.8 POWER SYSTEM STUDY REPORTS

- A. Preparation of Power System Study Reports: Prepare and submit the following:
 - 1. 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 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) Revisions to electrical equipment required by study.
 - d. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.
 - e. 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.

f. 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.

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 based on fault-point X/R ratio; based on calculated symmetrical value multiplied by 1.6; and 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 symmetrical basis.
 - g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

2. Overcurrent Protection Device 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 kVA and voltage ratings.
 - 4) Motor and generator designations and kVA ratings.
 - 5) Switchgear, switchboard, motor-control center, and panelboard designations.
 - 6) Revisions to electrical equipment required by study.
- d. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.
 - 1) Phase and Ground Relays:
 - a) Device tag.
 - b) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - c) Recommendations on improved relaying systems, if applicable.
 - 2) Circuit Breakers:
 - a) Adjustable pickups and time delays (long time, short time, and ground).
 - b) Adjustable time-current characteristic.
 - c) Adjustable instantaneous pickup.
 - d) Recommendations on improved trip systems, if applicable.
 - 3) 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 switching schemes and for emergency periods where power source is local generation. Show the following information:
 - 1) Device tag and title, one-line diagram with legend identifying portion of system covered.
 - 2) Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
 - 3) Identify 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) Largest feeder circuit breaker in each motor-control center and panelboard.
 - 5) Maintain selectivity for tripping currents caused by overloads.
 - 6) Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
 - 7) Provide adequate time margins between device characteristics such that selective operation is achieved.
 - 8) Comments and recommendations for system improvements.
3. Arc-Flash Hazard 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, showing the following:
 - 1) Protective device designations and ampere ratings.
 - 2) Conductor types, sizes, and lengths.
 - 3) Transformer 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. Short-circuit study output data.
 - e. Overcurrent protective device coordination study report contents.
 - f. Arc-Flash Study Output Reports:
 - 1) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in 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 symmetrical basis.
 - g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.
 - g. 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) Restricted approach boundary.
- 6) Limited approach boundary.
- 7) Working distance.
- 8) Incident energy.
- 9) Hazard risk category.
- 10) Recommendations for arc-flash energy reduction.

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

3.9 DIGITAL-TWIN MODELING

- A. Create digital-twin model of as-constructed facility's electrical power system.

3.10 FIELD ADJUSTMENT FOR DEVICE COORDINATION

- A. Adjust relay and protective device settings in accordance with recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "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 must be by qualified low-voltage electrical testing and inspecting agency.
 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 adjustable overcurrent protective devices.

3.11 WARNING LABELING OF ARC-FLASH HAZARDS

- A. Apply one arc-flash label on front cover of each section of equipment for each equipment included in study, including each piece of equipment listed below:
 1. Medium-voltage switchgear.
 2. Medium-voltage switches.
 3. Medium voltage transformers.
 4. Generators
 5. Low-voltage switchgear.
 6. Switchboards.
 7. Panelboards.
 8. Motor-control centers.
 9. Low voltage transformers.
 10. Safety switches.
 11. Control panels.
- B. Base arc-flash label data on highest values calculated at each location.
- C. Machine print warning labels with no handwritten or field-applied markings.

- D. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.
- E. Indicate on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.
 - 1. Indicate arc-flash energy.
 - 2. Indicate protection level required.

END OF SECTION 260573

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electrical equipment connected to Normal electrical systems, including the following:
 - a. Motor-control centers.
 - b. Transformers.
 - c. Secondary service electrical systems.
 - d. Distribution and branch-circuit panelboards.
 - e. Lightning protection systems.
 - f. Grounding systems.
2. Electrical equipment connected to Essential electrical systems that provide an alternative source of power in the absence of power from the Normal electrical system, including the following:
 - a. Motor-control centers.
 - b. Primary and secondary service electrical systems.
 - c. Distribution and branch-circuit panelboards.
 - d. Lighting protection systems.
 - e. Grounding systems.
 - f. Generators.
 - g. UPS.
3. Controls and instrumentation, including the following:
 - a. Equipment monitoring systems.
 - b. Energy monitoring and control systems.
 - c. Electrical metering and metering system.
 - d. Demand response systems.
 - e. Lighting control systems.
 - f. Security systems.
 - g. Fire-alarm systems.
4. Systems testing and verification, including Normal and Essential electrical systems, and transitions from Normal to Essential electrical systems and back.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
2. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
3. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. BoD: Basis-of-Design Document, as defined in Section 019113 "General Commissioning Requirements."
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. OPR: Owner's Project Requirements, as defined in Section 019113 "General Commissioning Requirements."
- E. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Construction Checklists by CxA: Draft construction checklists will be created by CxA for Contractor review.
- B. Construction Checklists by Contractor: Include the following and comply with requirements in Section 019113 "General Commissioning Requirements" for construction checklists:
 - 1. Instrumentation and control for electrical systems.
 - 2. Instrumentation and control for lighting control systems.
 - 3. Low-voltage power cables.
 - 4. Control voltage power cables.
 - 5. Electrical feeders and branch circuits.
 - 6. Dry-type transformers.
 - 7. Instrument transformers.
 - 8. Switchgear and switchboard assemblies rated 1200 A or greater.
 - 9. Metal-enclosed bus duct.
 - 10. Motor-control centers.
 - 11. Low-voltage motor starters.
 - 12. Low-voltage air circuit breakers.
 - 13. Low-voltage insulated case circuit breakers.
 - 14. Low-voltage network protectors.
 - 15. Low-voltage air switches.
 - 16. Low-voltage surge protective devices.
 - 17. Metering devices.
 - 18. Molded-case circuit breakers.
 - 19. Low-voltage power circuit breakers.
 - 20. Grounding systems.
 - 21. Ground-fault protection systems.
 - 22. Panelboards.
 - 23. Receptacles and devices.
 - 24. Engine generators.
 - 25. Automatic transfer switches.
 - 26. Variable-frequency drives.
 - 27. AC synchronous motors and generators.
 - 28. AC induction motors and generators.

- 29. DC motors and generators.
- 30. Battery systems.
- 31. Battery chargers.
- 32. UPS systems.
- 33. Lighting.

1.4 QUALITY ASSURANCE

- A. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform electrical Cx work, perform the following:
 - 1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
 - a. Equipment/instrument identification number.
 - b. Planned Cx application or use.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 - 2. Test equipment and instrumentation must meet the following criteria:
 - a. Capable of testing and measuring performance within the specified acceptance criteria.
 - b. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - c. Be maintained in good repair and operating condition throughout duration of use on Project.
 - d. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- B. Proprietary Test Instrumentation and Tools:
 - 1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
 - a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
 - 1) Instrument or tool identification number.
 - 2) Equipment schedule designation of equipment for which the instrument or tool is required.
 - 3) Manufacturer, make, model, and serial number.
 - 4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Electrical proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

- A. Prepare detailed construction checklists for electrical systems, subsystems, equipment, and components. Complete and submit construction checklists.

3.2 CONSTRUCTION CHECKLIST REVIEW

- A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.
- B. Return draft Construction Checklist review comments within 10 days of receipt.
- C. When review comments have been resolved, CxA will provide final construction checklists, marked "Approved for Use, (date)."
- D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 GENERAL TESTING REQUIREMENTS

- A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved Shop Drawings and submittals.
- B. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.
- E. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.
- F. Construction Checklists: Prepare and submit detailed construction checklists for electrical systems, subsystems, equipment, and components.
 - 1. Contributors to development of construction checklists must include, but are not limited to, the following:
 - a. Electrical systems and equipment installers.

- b. Electrical instrumentation and controls installers.
- G. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- H. If tests cannot be completed because of a deficiency outside the scope of the electrical system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.
- I. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.
- J. Coordinate schedule with, and perform Cx activities at the direction of the CxA.
- K. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Sections specifying electrical systems and equipment.
- L. Provide qualified testing and inspecting agency personnel in accordance with Section 260010 "Supplemental Requirements for Electrical," instrumentation, tools, and equipment to complete and document the following:
 - 1. Performance tests.
 - 2. Demonstration of a sample of performance tests.
 - 3. Cx tests.
 - 4. Cx test demonstrations.

3.4 Cx TESTS FOR ELECTRICAL SYSTEMS

- A. Verification of Normal Electrical System Operation:
 - 1. Prerequisites: Acceptance of results for construction checklists for Division 26 electrical components associated with Normal electrical system.
 - 2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
 - 3. Test Purpose: Verify operation of Normal electrical system.
 - 4. Test Conditions: Energize components of Normal electrical system, one at a time.
 - 5. Acceptance Criteria: Proper operation of Normal electrical system over a 24hour period.
- B. Verification of Essential Electrical System Operation:
 - 1. Prerequisites:
 - a. Acceptance of results for construction checklists for Division 26 electrical components associated with Essential electrical system.

- b. Completion of "Verification of Normal Electrical System Operation" tests.
 - 2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
 - 3. Test Purpose: Verify operation of Essential electrical system.
 - 4. Test Conditions:
 - a. Energize components of Normal electrical system.
 - b. Simulate a failure of Normal electrical system.
 - 5. Acceptance Criteria: Transfer of power from Normal to Essential electrical system within OPR.
- C. Verification of Control and Instrumentation:
- 1. Prerequisites: Acceptance of results for construction checklists.
 - a. Section 260913 "Electrical Power Monitoring and Control."
 - b. Section 260926 "Lighting Control Panelboards."
 - c. Section 260936 "Modular Dimming Controls."
 - d. Section 260943.16 "Addressable-Luminaire Lighting Controls."
 - e. Section 260943.23 "Relay-Based Lighting Controls."
 - f. Section 262713 "Electricity Metering."
- D. Test Purpose: Verify operation of control and monitoring systems for Normal and Essential electrical systems.
- E. Test Conditions:
- 1. Energize components of Normal electrical system.
 - 2. Test operation of equipment.
- F. Acceptance Criteria: Operation of equipment according to OPR.

END OF SECTION 260800

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Outdoor photoelectric switches.
3. Daylight-harvesting controls.
4. Business occupancy and vacancy sensors.
5. Storage occupancy sensors.
6. Outdoor motion sensors.
7. Industrial control switches.
8. Emergency lighting controls.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding of lighting control devices referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 262726 "Wiring Devices" for wall-box dimmers and manual light switches.

1.2 DEFINITIONS

- A. BCELTS: Branch circuit emergency lighting transfer switch.
- B. DPDT: Double pole double throw.
- C. DPST: Double pole single throw.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. PIR: Passive infrared.
- G. SPDT: Single pole double throw.

- H. SPST: Single pole single throw.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.
 - 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Diagrams for power, signal, and control wiring.
 - 4.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Software and firmware service agreement.

1.6 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multiteam projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician IV certification.
- D. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with applicable IES standards.

1.7 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that installed lighting control devices perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: Four years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that lighting control devices perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
 - 2. Initial Extended-Warranty Period: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.
 - 3. Follow-On Extended-Warranty Period: 10 years from date of Substantial Completion; full coverage for materials only, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements:

1. Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Must comply with CCR Title 24.

2.2 TIME SWITCHES

2.3 OUTDOOR PHOTOELECTRIC SWITCHES

A. UL WJFX - Solid-State Outdoor Photoelectric Switch, Flexible Mounting

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
3. Standard Features:
 - a. Solid state, with [SPST] [DPST] <Insert configuration> dry contacts rated for [1000 W incandescent] [or] [1800 VA inductive] <Insert value>, to operate connected relay, contactor coils, or microprocessor input; and compatible with drivers and LED lamps.
 - b. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - c. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), 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.
 - d. Time Delay: Fifteen-second minimum, to prevent false operation.
 - e. Surge Protection: Metal-oxide varistor.
 - f. 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.
 - g. Failure Mode: Luminaire stays ON.

B. UL WJFX - Solid-State Outdoor Photoelectric Switch, Luminaire-Mounted:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
3. Standard Features:

- a. Solid state, with DPST dry contacts rated for 1800 VA, to operate connected load, and compatible with LED lamps and drivers.
- b. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
- c. Time Delay: Thirty-second minimum, to prevent false operation.
- d. Lightning Arrester: Air-gap type.
- e. Mounting: Twist lock complying with ANSI C136.10, with base.
- f. Failure Mode: Luminaire stays ON.

C. UL WJFX - Solid-State, Low-Voltage, Outdoor Photoelectric Switch

- 1. Source Limitations: Obtain products from single manufacturer.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
- 3. Standard Features:
 - a. Solid state; one set of N.O. dry contacts rated for operating voltage of lighting control system, to operate connected load, and compatible with luminaire, power pack, and lighting control panelboard.
 - b. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
 - c. Time Delay: Thirty-second minimum, to prevent false operation.
 - d. Mounting: 1/2 inch (13 mm) threaded male conduit.
 - e. Failure Mode: Luminaire stays ON.
 - f. Power Pack:
 - 1) Dry contacts rated for 20 A LED load at 120 and 277 V(ac), Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - a) LED status lights to indicate load status.
 - b) Plenum rated.
 - 2) Digital controller capable of accepting four 8PSJ inputs with **two** outputs rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc), Class 2 power source.
 - a) With integral current monitoring.
 - b) Compatible with digital addressable lighting interface.
 - c) Plenum rated.

2.4 DAYLIGHT-HARVESTING CONTROLS

A. UL WJCT - Daylight-Harvesting Digital Control Dimmer :

- 1. Source Limitations: Obtain products from single manufacturer.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Photoelectric Switches: UL CCN WJCT, including UL 773A.
- 3. Standard Features:
 - a. Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.
 - b. System programming is done with two handheld, remote-control tools.
 - 1) Initial setup tool.
 - 2) 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] [separate]** power pack **[mounted on luminaire]**, to detect changes in indoor lighting levels that are perceived by the eye.
 - d. Sensor Output: 0-10 V(dc) to operate luminaires. Sensor is powered by controller unit.
 - e. Light-Level Sensor Set-Point Adjustment Range: As noted in the Lighting Control Zone Matrix on Plans.
 - f. Power Pack: Digital controller capable of accepting four 8PSJ inputs with two output(s) rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc) Class 2 power source.
 - 1) With integral current monitoring.
 - 2) Compatible with digital addressable lighting interface.
 - 3) Plenum rated.
- 4. Sequence of Operation: 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.

2.5 BUSINESS OCCUPANCY AND VACANCY SENSORS

- A. Dual-Technology, Passive-Infrared (PIR) and Ultrasonic, Occupancy or Vacancy Sensor
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - b. Appliance Controls: UL CCN ATNZ, including UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
 - 3. Standard Features:
 - a. Wall or Ceiling mounted, solid-state indoor occupancy and vacancy sensors. Refer to plans for mounting.
 - b. Separate power pack.
 - c. **[Hardwired connection to switch[and BAS]; and BAS and lighting control system].**

- d. Sensitivity Adjustment: Separate for each sensing technology.
 - e. Detector Sensitivity: Detect occurrences of 6 inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch (23 200 sq. mm), and detect a person of average size and weight moving not less than 12 inch (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inch/s (305 mm/s).
 - 1) Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft (93 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.
 - 2) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 sq. ft (220 sq. m) when mounted 48 inch (1200 mm) above finished floor.
4. 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.
 - b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

2.6 OUTDOOR MOTION SENSORS

A. Solid-State Outdoor Motion Sensor :

- 1. Source Limitations: Obtain products from single manufacturer.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:
 - a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
 - b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.
 - c. Intrusion Detection Units: UL CCN ANSR, including UL 639.
- 3. Standard Features:
 - a. PIR type, weatherproof. Detect occurrences of 6 inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch (23 200 sq. mm).
 - b. Switch Rating:
 - 1) Luminaire-Mounted Sensor: 500 VA fluorescent/LED >.
 - 2) Separately Mounted Sensor: Dry contacts rated for 20 A [driver] [or] [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.

- 3) Switch Type: Single pole with bypass switch to override the "on" function in case of sensor failure.
- c. Voltage: 277 V type.
- d. Detector Coverage:
 - 1) Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft (84 sq. m).
 - 2) Long Range: 180-degree field of view and 110 ft (34 m) detection range.
- e. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lx). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
- f. Time Delay:
 - 1) Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 - 2) Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
- g. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
- h. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as "raintight" in accordance with UL 773A.

2.7 EMERGENCY LIGHTING CONTROLS

A. UL FTBR - Automatic Load Control Relay (ALCR) :

- 1. Source Limitations: Obtain products from single manufacturer.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Emergency Lighting and Power Equipment: UL CCN FTBR, including UL 924.
- 3. Standard Features:
 - a. N.C., electrically held relay.
 - b. Coil Rating: 277 V.

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 SELECTION OF CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than 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 18 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 16 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 INSTALLATION OF LIGHTING CONTROL DEVICES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Maintenance: NFPA 70B.
 - 3. Electrical Safety: NFPA 70E.
 - 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 5. Communications Work: BICSI N1.
 - 6. Life Safety and Means of Egress Work: NFPA 101.
 - 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 8. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. 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.
 - 2. 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 instructions.
 - 3. Installation of Wiring:
 - a. Conduit: Minimum conduit size is 1/2 inch (13 mm).
 - b. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's published instructions.
 - c. Size conductors in accordance with lighting control device manufacturer's published instructions unless otherwise indicated.
 - d. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.
- D. Interfaces with Other Work:

1. Identification: Provide labels for lighting control devices and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - c. Identify controlled circuits in lighting contactors.
 - d. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
 - e. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

- A. Administrant for Electrical Power Tests and Inspections:
 - 1.
 2. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- B. Administrant for Lighting Tests and Inspections:
 1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- C. Field tests must be witnessed by Architect
- D. Tests and Inspections:
 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.
- E. Nonconforming Work:
 1. Lighting control devices will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.
 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual

occupied conditions. Provide up to two visits to the Project site during other-than-normal occupancy hours for this purpose. Some of the Work may be required during hours of darkness.

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.

3.6 CLOSEOUT ACTIVITIES

A. Demonstration:

1. With assistance from factory-authorized service representatives, demonstrate to Owner's maintenance and clerical personnel how to operate the following systems and equipment:
 - a. Lighting control devices.

B. Training:

1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain lighting control devices.

3.7 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for two years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.
 - a. Upgrade Notice: Not less than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 260923

SECTION 260943.23 - RELAY-BASED LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lighting control relay panels.
2. Networked lighting control panels.
3. Manual switches and cover plates.
4. Field-mounted signal sources.
5. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and cover plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.
4. Operational documentation for software and firmware.

B. Shop Drawings: For each relay panel and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than Type 1.
3. Detail wiring partition configuration, current, and voltage ratings.
4. Short-circuit current rating of relays.

5. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
6. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
7. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
8. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
9. Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - a. Show interconnecting signal and control wiring, and interface devices that show compatibility of inputs and outputs.
 - b. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

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. Lighting Control Relays: Equal to 1 percent of amount installed for each size indicated, but no fewer than 5.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panels for installation in accordance with NECA 407.

1.7 WARRANTY

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of standalone multipreset modular dimming controls perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.
1. Initial Extended Warranty Period: Four year(s) from date of Substantial Completion, for labor, materials, and equipment.

2. Follow-on Extended Warranty Period: Eight year(s) from date of Substantial Completion, for materials that failed because of transient voltage surges only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, must open or close one or more lighting control relays in the lighting control panels. Any combination of inputs must be programmable to any number of control relays.
- B. Interface with HVAC DDC System: Hardware and software must interface with HVAC DDC system to monitor, control, display, and record data for use in processing reports. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 1. Hardwired Points:
 - a. Monitoring: On-off status>.
 - b. Control: On-off operation,
 2. Communication Interface: Comply with **ISO/IEC 14908-1** "MODBUS Application Protocol Specification". The communication interface must enable the HVAC DDC system operator to remotely control and monitor lighting from a HVAC DDC system operator workstation. Control features and monitoring points displayed locally at lighting panel must be available through the HVAC DDC system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- C. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.
- D. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- E. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
- F. Comply with UL 916.

2.2 NETWORKED LIGHTING CONTROL PANELS

- A. Description: Lighting control panels using mechanically latched relays to control lighting and appliances. The panels must be capable of being interconnected with digital communications to appear to the operator as a single lighting control system.
- B. Lighting Control Panels:
 1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
 2. A vertical barrier separating branch circuits from control wiring.

- C. Main Control Unit: Installed in the main lighting control panel only; powered from the branch circuit of the standard control unit.
1. Ethernet Communications: Comply with TCP/IP protocol. The main control unit must provide for programming of all control functions of the main and all networked slave lighting control panels including timing, sequencing, and overriding.
 2. Protocol: Controllers must support serial MS/TP and Ethernet IP communications in accordance with ISO/IEC 14908-1 "MODBUS Application Protocol Specification", and must be able to communicate directly via DDC system for HVAC TIA-485 serial networks and Ethernet 10Base-T networks as a native device.
 3. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard browser.
 - a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
 - b. Panel summary showing the master and slave panels connected to the controller.
 - c. Controller diagnostic information.
 - d. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens must also allow direct breaker control and zone overrides.
 4. Timing Unit:
 - a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
 - b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
 - c. Four independent schedules, each having 24 time periods.
 - d. Schedule periods settable to the minute.
 - e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
 - f. 21 special date periods.
 5. Time Synchronization: The timing unit must be updated not less than every 4 hour(s) with the network time server.
 6. Sequencing Control with Override:
 - a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
 - b. Sequencing control must operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
 - c. Override control must allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
 - d. Override control "blinking warning" must warn occupants approximately five minutes before actuating the off sequence.
 - e. Activity log, storing previous relay operation, including the time and cause of the change of status.
 - f. Download firmware to the latest version offered by manufacturer.
- D. Standard Control Unit, Installed in All Lighting Control Panels: Contain electronic controls for programming the operation of the relays in the control panel, contain the status of relays, and contain communications link to enable the digital functions of the main control unit. Comply with UL 916.

1. Electronic control for operating and monitoring individual relays, and display relay on-time.
2. Nonvolatile memory must retain all setup configurations. After a power failure, the controller must automatically reboot and return to normal system operation.
3. Integral keypad and digital-display front panel for local setup, including the following:
 - a. Blink notice, time adjustable from software.
 - b. Ability to log and display relay on-time.
 - c. Capability for accepting downloadable firmware so that the latest production features may be added in the future without replacing the module.

E. Relays:

1. Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating must be not less than 5 kA. Control must be digital control network.
2. Electrically operated, mechanically held single-pole switch, rated at 20 A at 120 V for tungsten, 30 A at 277 V for ballast, 1.5 hp at 120 V, and 3 hp at 277 V. Short-circuit current rating must be not less than 14 kA. Control must be digital control network.

F. Power Supply: NFPA 70, Class 2, UL listed, sized for connected equipment, plus not less than 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, control-voltage inputs, field-installed occupancy sensors, and control-voltage photo sensors.

G. Operator Interface: At the main control unit, provide interface for a tethered connection of a portable PC running MS Windows for configuring all networked lighting control panels using setup software designed for the specified operating system. Include one portable device for initial programming of the system and training of Owner's personnel. That device must remain the property of Owner.

H. Software:

1. Menu-driven data entry.
2. Online and offline programming and editing.
3. Provide for entry of the room or space designation for the load side of each relay.
4. Monitor and control all relays, showing actual relay state and the name of the automatic actuating control, if any.
5. Size the software appropriate to the system.

2.3 MANUAL SWITCHES AND COVER PLATES

A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.

1. Match color and style specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

B. Cover Plates: Single and multigang cover plates as specified in Section 262726 "Wiring Devices."

- C. Legend: Engraved or permanently silk-screened on cover plate where indicated. Use designations indicated on Drawings.

2.4 FIELD-MOUNTED SIGNAL SOURCES

- A. Daylight Harvesting Switching Controls: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal must be compatible with the relays.
- B. Indoor Occupancy Sensors and Extreme-Temperature Occupancy Sensors: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal must be compatible with the relays.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: 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 Cables: Multiconductor cable with copper conductors not smaller than No. 18AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 16 AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- D. Twisted-Pair Data Cable: Category 6
 - 1. Comply with requirements for twisted pair cabling in Section 260523 "Control-Voltage Electrical Power Cables."
 - 2. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panels in accordance with NECA 407.
- B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WIRING

- A. Wiring Methods:

1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters.
 2. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, accessible ceiling spaces, and gypsum board partitions where unenclosed wiring method may be used.
 3. Install conductors and cables concealed in accessible ceilings, walls, and floors where possible.
 4. Conceal raceway and cables except in unfinished spaces.
 5. Provide plenum-rated cable, where installed exposed or in open cable tray, within environmental airspaces, including plenum ceilings.
 6. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 7. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."
- B. 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 INSTALLATION OF PANELS

- A. Install panels and accessories in accordance with NECA 407.
- B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Mount top of trim 90 inch (2286 mm) above finished floor unless otherwise indicated.
- D. Mount panel cabinet plumb and rigid without distortion of box.
- E. Install filler plates in unused spaces.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by Architect.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers described below and low-voltage surge arrestors. Certify compliance with manufacturer's test parameters.

a. Circuit-Breaker Tests:

- 1) Compare nameplate with Drawings and Specifications.
- 2) Inspect physical and mechanical conditions.
- 3) Inspect anchorage and alignment.
- 4) Verify that the units are clean.
- 5) Operate the circuit breaker to ensure smooth operation.
- 6) Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a) A low-resistance ohmmeter.
 - b) Verify tightness of bolted electrical connections by calibrated torque wrench.
 - c) Thermographic survey.
- 7) Inspect operating mechanism, contacts, and arc chutes in unsealed units.
- 8) Perform adjustments for final protective device settings in accordance with the overcurrent protective device coordination study. Comply with requirements in Section 260573.16 "Coordination Studies."
- 9) 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 pole using manufacturer's published data.
- 10) Perform a contact/pole-resistance test.
- 11) Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be for one minute. Follow manufacturer's instructions for solid-state units.
- 12) Determine long-time pickup and delay by primary current injection.
- 13) Determine short-time pickup and delay by primary current injection.
- 14) Determine ground-fault pickup and time delay by primary current injection.
- 15) Determine instantaneous pickup by primary current injection.
- 16) Test functions of the trip unit by means of secondary injection.
- 17) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
- 18) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset trip logs and indicators.
- 19) Verify operation of charging mechanism.

b. Surge Arrestor Tests:

- 1) Compare nameplate with the Contract Documents.
- 2) Inspect physical and mechanical conditions.
- 3) Inspect anchorage, alignment, grounding, and clearances.
- 4) Verify that the units are clean.
- 5) Inspect bolted electrical connections for high resistance using one or more of the following methods:

- a) Low-resistance ohmmeter.
 - b) Verify tightness of bolted electrical connections by calibrated torque wrench.
 - 6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - 7) Perform an insulation-resistance test on each arrestor, phase terminal-to-ground using voltage in accordance with manufacturer instructions.
 - 8) Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding tests.
- C. Nonconforming Work:
- 1. Lighting control panel will be considered defective if it does not pass tests and inspections.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.
- E. Manufacturer Services:
- 1. Engage factory-authorized service representative to support field tests and inspections.

3.6 SYSTEM STARTUP

- A. Engage a factory-authorized service representative to perform startup service.
- 1. Complete installation and startup checks in accordance with manufacturer's instructions.
 - 2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system in accordance with approved configuration schedules, time-of-day schedules, and input override assignments.

3.7 ADJUSTING

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

3.8 MAINTENANCE

- A. Software and Firmware Service Agreement:
- 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for **[two]** <Insert number> years.
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within **[two]** <Insert number> years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.

- a. Upgrade Notice: No fewer than 30days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

END OF SECTION 260943.23

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - b. 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 field connections.
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.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Transformer temporary heating, working clearances, anchoring, torque values, and insulation-resistance testing.
- B. Source quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: On receipt, inspect for and note 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 warm, dry, and temperature-stable location in original shipping packaging.
- C. Temporary Heating: Apply temporary heat in accordance with manufacturer's published instructions within enclosure of ventilated-type units, throughout periods during which equipment is not energized and when transformer is not in 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. Source Limitations: Obtain each type of transformer from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 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 qualified electrical testing laboratory recognized by authorities having jurisdiction.
- 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 transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.
 - 2. Core volume must allow efficient transformer operation at 10 percent above nominal tap voltage.
 - 3. Grounded to enclosure.
- C. 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: Welded.
- D. Encapsulation: Transformers smaller than 30 kVA must have core and coils completely resin encapsulated.
- E. Enclosure: Ventilated.
 - 1. Core and coil must be encapsulated within resin compound using 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. Environmental Protection:
 - a. Indoor: UL 50E, Type 2.
 - b. Outdoor: UL 50E, Type 4X, Stainless Steel.
 - 5. Finish Color: ANSI 61 gray weather-resistant enamel.
- F. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.
- 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 two 2.5 percent taps below normal full capacity.
- I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with 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 maximum of 115 deg C rise above 40 deg C ambient temperature.
- K. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.
- L. Electrostatic Shielding: Windings must have 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 shield.
- M. Wall Brackets: Wall brackets fabricated from design drawings signed and sealed by qualified structural professional engineer.
- N. Low-Sound-Level Requirements: Maximum sound levels when factory tested in accordance with IEEE C57.12.91, as follows:
 1. 9.00 kVA and Less: **[40 dB(A-weighted)]** <Insert dB(A-weighted)>.
 2. 9.01 to 30.00 kVA: **[45 dB(A-weighted)]** <Insert dB(A-weighted)>.
 3. 30.01 to 50.00 kVA: **[45 dB(A-weighted) for K-factors of 1, 4, and 9] [48 dB(A-weighted) for K-factors of 13 and 20]** <Insert dB(A-weighted)>.
 4. 50.01 to 150.00 kVA: **[50 dB(A-weighted) for K-factors of 1, 4, and 9] [53 dB(A-weighted) for K-factors of 13 and 20]** <Insert dB(A-weighted)>.
 5. 150.01 to 300.00 kVA: **[55 dB(A-weighted) for K-factors of 1, 4, and 9] [58 dB(A-weighted) for K-factors of 13 and 20]** <Insert dB(A-weighted)>.
 6. 300.01 to 500.00 kVA: **[60 dB(A-weighted) for K-factors of 1, 4, and 9] [63 dB(A-weighted) for K-factors of 13 and 20]** <Insert dB(A-weighted)>.
 7. 500.01 to 700.00 kVA: **[62 dB(A-weighted) for K-factors of 1, 4, and 9] [65 dB(A-weighted) for K-factors of 13 and 20]** <Insert dB(A-weighted)>.
 8. 700.01 to 1000.00 kVA: **[64 dB(A-weighted) for K-factors of 1, 4, and 9] [67 dB(A-weighted) for K-factors of 13 and 20]** <Insert dB(A-weighted)>.
 9. 1000.01 to 1500.00 kVA: <Insert dB(A-weighted)>.

2.4 IDENTIFICATION

- A. Nameplates:
 1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."
 2. Self-adhesive label for distribution transformers. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Testing Administrant: Engage qualified electrical testing agency to evaluate transformer.
- B. Factory Tests and Inspections: Test and inspect assembled system, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C57.12.01 and IEEE C57.12.91 before delivering to site. Affix label with name and date of qualified electrical testing laboratory's certification of system compliance on control units.
 1. Resistance measurements of windings at rated voltage connections and at tap connections.
 2. Ratio tests at rated voltage connections and at 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. Line-side to ground.
 - b. Load-side to ground.
 - c. Line-side to load-side.
 9. Temperature tests.
 10. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project
Conduct prototype sound-level tests on production-line products.
- C. Nonconforming Work:
1. System equipment that does not pass tests and inspections will be considered defective.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published 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 must be 5 Ω at location of transformer.
- E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may 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 from design drawings signed and sealed by qualified structural professional engineer.
 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
 2. Brace wall-mounted transformers as specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems"
- B. Install transformers level and plumb on concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

- C. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions, seismic requirements 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 in accordance with manufacturer's published instructions.
- E. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals in accordance with 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 conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections:
 - 1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:
 - a. Visual and Mechanical Inspection.
 - 1) Inspect physical and mechanical condition.
 - 2) Inspect anchorage, alignment, and grounding.
 - 3) Verify that resilient mounts are free and that shipping brackets have been removed.
 - 4) Verify that unit is clean.
 - 5) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 6) Verify that as-left tap connections are as specified.
 - 7) Verify presence of surge arresters and that their ratings are as specified.
 - b. Electrical Tests:

- 1) Measure resistance at windings, taps, and bolted connections.
 - 2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
 - 3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
 - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
2. Large (Larger Than 167 kVA Single Phase or 500 kVA Three Phase) Dry-Type Transformer Field Tests:
 - a. Visual and Mechanical Inspection:
 - 1) Inspect physical and mechanical condition.
 - 2) Inspect anchorage, alignment, and grounding.
 - 3) Verify that resilient mounts are free and that shipping brackets have been removed.
 - 4) Verify that unit is clean.
 - 5) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 6) Verify that as-left tap connections are as specified.
 - 7) Verify presence of surge arresters and that their ratings are as specified.
 - b. Electrical Tests:
 - 1) Measure resistance at windings, taps, and bolted connections.
 - 2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
 - 3) Perform power-factor or dissipation-factor tests on windings.
 - 4) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
 - 5) Perform excitation-current test on each phase.
 - 6) Perform applied voltage test on line- and load-side windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
 - 7) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- C. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.
- D. Nonconforming Work:
 1. Transformer will be considered defective if it does not pass tests and inspections.
 2. Remove and replace units that do not pass tests or inspections and retest as specified above.

- E. Assemble and submit test and inspection reports.
- F. Manufacturer Services:
 - 1. Engage factory-authorized service representative to [support] [supervise] field tests and inspections.

3.5 ADJUSTING

- A. Record transformer secondary voltage at 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 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.

3.7 MAINTENANCE

- A. Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections.
 - 1. Use 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 another at 11 months after Substantial Completion.
 - 3. Prepare certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 262213

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Switchboards.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.19 "Power System Studies" for arc-flash analysis and arc-flash label requirements.

1.2 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.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Switchboards.
2. Overcurrent protective devices.
3. Surge protection devices.
4. Ground-fault protection devices.
5. Accessories.
6. Other components.
7. 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 UL 50E, 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 utility company's metering provisions with indication of approval by utility company.
 7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 9. 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.
 10. Include diagram and details of proposed mimic bus.
 11. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Field Quality-Control Submittals:
1. Field Quality-Control Reports:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:
1. Handling, storing, and providing temporary heat.
 2. Mounting accessories and anchoring devices.
 3. Testing and adjusting overcurrent protective devices.
- B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: Furnish to Owner spare parts, for repairing switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

SWITCHBOARDS

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. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 4. 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.
 5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 2. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
 3. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
 4. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

1.7 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 in accordance with NEMA PB 2.1.

1.8 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed switchboard perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that switchboard performs in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended-warranty period.

1. Follow-On Extended-Warranty Period: **Five]** years from date of Substantial Completion; prorated coverage for materialsonly, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

- A. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, 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: Refer to One-Line Diagram.
- J. Indoor Enclosures: Steel, UL 50E, Type 1 .
- K. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over rust-inhibiting primer on treated metal surface.
- L. Barriers: Between adjacent switchboard sections.
- M. Insulation and isolation for main and vertical buses of feeder sections.
- N. Service Entrance Rating: Switchboards intended for use as service entrance equipment may contain from one to six service disconnecting means with overcurrent protection, neutral bus with disconnecting link, grounding electrode conductor terminal, and main bonding jumper.
- O. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If

SWITCHBOARDS

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separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

- P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- Q. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.
- R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- S. 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 may form top, front, and sides. Top covers at rear must be easily removable for drilling and cutting.
 - 4. Bottom must be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 - 5. Cable supports must be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- T. 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 front of switchboard.
 - 2. Phase- and Neutral-Bus Material:
 - a. Hard-drawn copper of 98 percent conductivity.
 - b. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 - 3. Copper feeder circuit-breaker line connections.
 - 4. Tin-plated aluminum feeder circuit-breaker line connections.
 - 5. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 - 6. Ground Bus: 1/4 by 2 inch (6 by 50 mm-)hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
 - 7. 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.
 - 8. 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.
 - 9. Neutral Buses: 100 percent of ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - 10. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

- U. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- V. 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.
- W. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 SURGE PROTECTION DEVICES

- A. SPDs: Listed and labeled in accordance with UL 1449, Type 1 .
- B. Features and Accessories:
 - 1. Integral disconnect switch.
 - 2. Internal thermal protection that disconnects SPD before damaging internal suppressor components.
 - 3. Indicator light display for protection status.
 - 4. Form-C contacts rated at 2 A and 24 V(ac) >, one normally open and one normally closed, for remote monitoring of protection status.
 - 5. Surge counter.
- C. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase may not be less than 250 kA. Peak surge current rating must be arithmetic sum of ratings of individual MOVs in each mode.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with **[480Y/277 V] [208Y/120 V]**, three-phase, four-wire circuits may not exceed the following:
 - 1. Line to Neutral: 1200 V for 480Y/277 V.
 - 2. Line to Ground: 1200 V for 480Y/277 V.
 - 3. Line to Line: 2000 V for 480Y/277 V.
- E. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits may not exceed the following:
 - 1. Line to Neutral: 700 V.
 - 2. Line to Ground: 700 V.
 - 3. Line to Line: 1000 V.
- F. SCCR: Equal or exceed 100 kA.
- G. Nominal Rating: 20 kA.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with **[series-connected rating] [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-replaceable 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^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6 mA trip).
 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30 mA trip).
 8. 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.
 - c. Application Listing: Appropriate for application.
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - h. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixedcircuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Standard function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Time adjustments for long- and short-time pickup.
 - c. Ground-fault pickup level, time delay, and I^2t response.
 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.

2.4 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy must be consistent with connected metering and relay devices.
 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy must be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
 - d. Megawatts: Plus or minus 1 percent.
 - e. Megavars: Plus or minus 1 percent.
 - f. Power Factor: Plus or minus 1 percent.
 - g. Frequency: Plus or minus 0.1 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- C. Analog Meters:
1. Meters: 4 inch (100 mm) diameter or 6 inch (150 mm) square, flush or semiflush, with anti-parallax 250-degree scales and external zero adjustment.
- D. Voltmeters: Cover expanded-scale range of nominal voltage plus 10 percent.

- E. Instrument Switches: Rotary type with off position.
 - 1. Voltmeter Switches: Permit reading of phase-to-phase voltages and, where neutral is indicated, phase-to-neutral voltages.
 - 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in closed-circuit condition at all times.
- F. Ammeters: 2-1/2 inch (64 mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
- G. Watt-Hour Meters and Wattmeters:
 - 1. Comply with ANSI C12.1.
 - 2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
 - 3. Suitable for connection to three- and four-wire circuits.
 - 4. Potential indicating lamps.
 - 5. Adjustments for light and full load, phase balance, and power factor.
 - 6. Four-dial clock register.
 - 7. Integral demand indicator.
 - 8. Contact devices to operate remote impulse-totalizing demand meter.
 - 9. Ratchets to prevent reverse rotation.
 - 10. Removable meter with drawout test plug.
 - 11. Semiflush mounted case with matching cover.
 - 12. Appropriate multiplier tag.
- H. Impulse-Totalizing Demand Meter:
 - 1. Comply with ANSI C12.1.
 - 2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
 - 3. Cyclometer.
 - 4. Four-dial, totalizing kilowatt-hour register.
 - 5. Positive chart drive mechanism.
 - 6. Capillary pen holding minimum of one month's ink supply.
 - 7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
 - 8. Capable of indicating and recording 15 -minute integrated demand of totalized system.

2.5 CONTROL POWER

- A. Control Circuits:
 - 1. 120 V(ac), supplied through secondary disconnecting devices from control-power transformer.
- B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to primary side of each control-power transformer at line side of associated main circuit breaker. 120 V secondaries connected through automatic transfer relays to ensure fail-safe automatic transfer scheme.
- C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

- D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards in accordance with NEMA PB 2.1.
 - 1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's published 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 in accordance with manufacturer's published 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 performance of equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

3.3 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Switchboards and Accessories: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 2.1.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:

SWITCHBOARDS

1. Equipment Mounting: Install switchboards on concrete base, 4 inch (100 mm) nominal thickness. Comply with requirements for concrete base specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - a. Install conduits entering underneath switchboard, entering under vertical section where conductors will terminate. Install with couplings flush with concrete base. Extend 2 inch (50 mm) above concrete base after switchboard is anchored in place.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch (450 mm) centers around full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, published instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to switchboards.
 - f. Anchor switchboard to building structure at top of switchboard if required or recommended by manufacturer.
2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Operating Instructions: Frame and mount 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.
5. Install filler plates in unused spaces of panel-mounted sections.
6. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - a. Set field-adjustable switches and circuit-breaker trip ranges.
7. Install spare-fuse cabinet.

3.4 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.
- C. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.
- D. Support and secure conductors within switchboard in accordance with NFPA 70.
- E. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.5 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 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 nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Mimic Bus:
 - 1. Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
 - 2. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce concise visual presentation of principal switchboard components and connections.
- E. Service Equipment Label: Labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
- F. Field tests and inspections must be witnessed by Architect .
- G. 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 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 in accordance with 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 infrared scan of each switchboard. Remove [front] [front and rear] panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:

- 1) Use 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.
- H. Nonconforming Work:
 1. Switchboard will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- I. Collect, assemble, and submit test and inspection reports, including certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- J. Manufacturer Services:
 1. Engage factory-authorized service representative to [support] [supervise] field tests and inspections.

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 "Power System Studies."

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature in accordance with manufacturer's published instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Panelboards.
2. Disconnecting and overcurrent protective devices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other requirements applicable to the Work for electrical, communications, and electronic safety and security systems on Project, including wiring methods.
4. Section 260529 "Hangers and Supports for Electrical Systems" specifies concrete bases and supports for panelboards installed by this Section.
5. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies seismic control devices, mounting devices, and anchoring devices installed by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
7. Section 260573 "Power System Studies" specifies short-circuit current studies, overcurrent protective device coordination studies, and arc-flash hazard analysis studies.
8. Section 260913 "Electrical Power Monitoring" specifies power monitoring and control systems installed by this Section.
9. Section 262813 "Fuses" specifies fuses and spare-fuse cabinets installed by this Section.
10. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies Type 1 and Type 2 surge protective devices installed by this Section.

1.2 DEFINITIONS

- A. MCCB: Molded-case circuit breaker.
- B. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:
1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 2. Include manufacturer's sample extended warranty language.

- 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. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
 - 7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for SPD as installed in panelboard.
 - 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 9. Include wiring diagrams for power, signal, and control wiring.
 - 10. Key interlock scheme drawing and sequence of operations.
 - 11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device. Include Internet link for electronic access to downloadable PDF of coordination curves.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- B. Manufacturer's published instructions.
- C. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Field reports for voltage monitoring and adjusting.
 - 3. Field reports for infrared scanning.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.

1.7 QUALIFICATIONS

- A. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

1.8 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 in accordance with NEMA PB 1.

1.9 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed panelboards perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that panelboards perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Follow-On Extended-Warranty Period: Five years from date of Substantial Completion; full coverage for materials only, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Fabricate and test panelboards in accordance with IEEE 344 to withstand seismic forces specified in Section 018123 "Facility Seismic and Wind Criteria."
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Comply with NEMA PB 1.
- E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: UL 50E, **Type 1**
 - b. Outdoor Locations: UL 50E, Type 4X .
 - c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 12.
 2. Height: 7 ft (2.13 m) maximum.
 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims must cover live parts and may have no exposed hardware.
 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims must cover live parts and may have no exposed hardware.
 5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 7. Finishes:
 - a. Panels and Trim: 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.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
- F. Phase, Neutral, and Ground Buses:
1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity].
 - a. Plating must run entire length of bus.
 - b. Bus must be fully rated for entire length.
 2. Interiors must be factory assembled into unit. Replacing switching and protective devices may not disturb adjacent units or require removing main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- G. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity].
 2. Terminations must 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 lug on neutral bar for each pole in panelboard.
 5. Ground Lugs and Bus-Configured Terminators: Compression type, with lug on bar for each pole in panelboard.
- H. Quality-Control Label: Panelboards or load centers must be labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers must have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

- I. Future Devices: Panelboards or load centers must have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
 - 1. Percentage of Future Space Capacity: 20.
- J. Panelboard Short-Circuit Current Rating:
 - 1. Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by qualified electrical testing laboratory recognized by authorities having jurisdiction. Include label or manual with size and type of allowable upstream and branch devices listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series-connected short-circuit rating.
 - a. Panelboards rated 240 V or less must have short-circuit ratings as shown on Drawings, but not less than 10 000 A(rms) symmetrical.
 - b. Panelboards rated above 240 V and less than 600 V must have short-circuit ratings as shown on Drawings, but not less than 14 000 A(rms) symmetrical.
 - 2. Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for 100 percent interrupting capacity.
 - a. Panelboards and overcurrent protective devices rated 240 V or less must have short-circuit ratings as shown on Drawings, but not less than 10 000 A(rms) symmetrical.
 - b. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V must have short-circuit ratings as shown on Drawings, but not less than 14 000 A(rms) symmetrical.

2.2 PANELBOARDS

- A. UL QEUY - Distribution Panelboard :
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Distribution Type Panelboards: UL CCN QEUY; including UL 67 and NEMA PB 1.
 - 3. Standard Features:
 - a. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1) For doors more than 36 inch (914 mm) high, provide two latches, keyed alike.
 - b. Mains: Per panel schedules.
 - 1) Location: Convertible between top and bottom.
 - 2) Main Breaker: Main lug interiors up to 400 A must be field convertible to main breaker.

- c. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: [Plug-in circuit breakers] [Bolt-on circuit breakers] [Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal].
 - d. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: [Bolt-on circuit breakers] [Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal].
 - e. Branch Overcurrent Protective Devices: Fused switches.
 - 4. Other Available Features Required by Project:
 - a. Surge Suppression: Factory installed as integral part of indicated panelboards, complying with UL 1449 SPD Type 2.
 - b. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - c. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure.
 - d. Do not mount neutral bus in gutter.
 - e. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - f. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- B. UL QEUY - Lighting and Appliance Branch-Circuit Panelboard:
- 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Lighting and Appliance Branch-Circuit Type Panelboards: UL CCN QEUY; including UL 67 and NEMA PB 1.
 - 3. Standard Features:
 - a. Mains: As indicated on Drawings
 - 1) Location: Convertible between top and bottom.
 - 2) Main Breaker: Main lug interiors up to 400 A must be field convertible to main breaker.
 - b. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
 - 4. Other Available Features Required by Project:
 - a. Surge Suppression: Factory installed as integral part of indicated panelboards, complying with UL 1449 SPD Type 2.
 - b. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure.
 - c. Do not mount neutral bus in gutter.
 - d. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - e. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

- f. Doors: Door-in-door construction with concealed hinges; secured with **flush** latch with tumbler lock; keyed alike. Outer door must permit full access to panel interior. Inner door must permit access to breaker operating handles and labeling, but current carrying terminals and bus must remain concealed.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. 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. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event must be recorded with type, phase, and magnitude of fault that caused trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long- and short-time adjustments.
 - 4) Ground-fault pickup level, time delay, and $I^2 T$ response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6 mA trip).
 - 6. GFPE Circuit Breakers: Class B ground-fault protection (30 mA trip).
 - 7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240 V, single-pole configuration.
 - 8. Subfeed Circuit Breakers: Vertically mounted.
 - 9. 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; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - 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: 24 V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.
 - h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - i. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
 - j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150A must have interchangeable rating plugs or electronic adjustable trip units.
 - k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - l. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
 - m. Multipole units enclosed in factory assembled to operate as single unit.
- B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
 - 1. Provide fuses and spare fuse cabinet.
 - 2. Fused Switch Features and Accessories:
 - a. Standard ampere ratings and number of poles.
 - b. Mechanical cover interlock with manual interlock override, to prevent opening of cover when switch is in on position. Interlock must prevent switch from being turned on with cover open. Operating handle must have lock-off means with provisions for three padlocks.

2.4 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing panelboards and related equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
 - 1. Keys: Two spares for each type of panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and GFPE Types: Two spares for each panelboard.
 - 3. 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.
 - 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to panelboards and related equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
 - 1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 - 2. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

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 in accordance with 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. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Panelboards: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 1.1.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 - 1. Equipment Mounting:
 - a. Install floor-mounted panelboards on cast-in-place concrete equipment base(s).
 - b. Attach panelboard to vertical finished or structural surface behind panelboard.
 - c. Mount surface-mounted panelboards to steel slotted supports 5/8 inch (16 mm) 1-1/4 inch (32 mm) in depth. Orient steel slotted supports vertically.
 - d. Provide seismic control devices.
 - 2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
 - 3. Provide mounting and anchoring devices.
 - 4. Mount top of trim 7.5 ft (2.3 m) above finished floor unless otherwise indicated.
 - 5. Mount panelboard cabinet plumb and rigid without distortion of box.
 - 6. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
 - 7. Install overcurrent protective devices and controllers not already factory installed.
 - a. Set field-adjustable, circuit-breaker trip ranges.
 - b. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver in accordance with manufacturer's published instructions.

8. 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.
9. Install filler plates in unused spaces.
10. Stub four 1 inch (25 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in future. Stub four 1 inch (25 mm) empty conduits into raised floor space or below slab not on grade.
11. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
12. Mount spare fuse cabinet in accessible location.

D. Interfaces with Other Work:

1. 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.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components.
- B. Install warning signs.
- C. Panelboard Nameplates: Label each panelboard with nameplate.
- D. Device Nameplates: Label each branch circuit device in power panelboards with nameplate.
- E. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles must be located on interior of panelboard door.
- F. Breaker Labels: Faceplate must list current rating, UL and IEC certification standards, and AIC rating.
- G. Circuit Directory:
 1. Provide directory card inside panelboard door, mounted in metal frame with transparent protective cover.
 - a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
 2. Provide computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 - a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
 3. Create 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.

3.4 FIELD QUALITY CONTROL

- A. Administrant for Low-Voltage Electrical Tests and Inspections:
 - 1. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
- 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. Field tests and inspections must be witnessed by Architect
- D. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Perform optional tests. Certify compliance with test parameters.
 - 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 infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- E. Nonconforming Work:
 - 1. Panelboards will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
 - 1. Include certified report that identifies panelboards included and that describes scanning results, with comparisons of two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- G. Manufacturer Services: Engage factory-authorized service representative to supervise field tests and inspections.

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.
- 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 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 panelboard, may not exceed 20 percent.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature in accordance with manufacturer's published instructions.

END OF SECTION 262416

SECTION 262716 - ELECTRICAL CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cabinets and cutout boxes.
2. Termination boxes.
3. Miscellaneous enclosures.
4. Rack or frame systems.
5. Enclosure-mounted power distribution.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
6. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding for RBBs referenced by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.
8. Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.

1.2 DEFINITIONS

- A. RBB: Rack bonding busbar, located in equipment cabinets and racks.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Custom Enclosures and Cabinets: Include plans, elevations, sections, and attachment details.
 2. Shop Drawings for Racks or Frames:
 - a. Include plans, elevations, sections, details, and attachments to other work.
 - b. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Include workspace requirements and access for cable connections.
 - d. Grounding: Indicate location of RBB and its mounting detail showing standoff insulators and wall-mounting brackets.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' published instructions.

1.5 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site electrical testing supervisors must possess active NICET EPT Technician [III] [IV] certification.
- D. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
1. On-site communications testing supervisor must have BICSI Technician (TECH) certification and documented training, and be experienced with testing communications equipment in accordance with BICSI testing standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 CABINETS AND CUTOUT BOXES

A. UL CYIV - Indoor Sheet Metal Cabinets :

1. Listing Criteria:

- a. UL CCN CYIV.
- b. Non-Environmental Characteristics: UL 50.
- c. Environmental Characteristics: UL 50E.

2. Standard Features:

- a. Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
- b. Degree of Protection: Type 1.

B. UL CYIV - Indoor Sheet Metal Cutout Boxes :

1. Listing Criteria:

- a. UL CCN CYIV.
- b. Non-Environmental Characteristics: UL 50.
- c. Environmental Characteristics: UL 50E.

2. Standard Features:

- a. Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
- b. Degree of Protection: Type 1

C. UL CYIV - Outdoor Sheet Metal Cabinets :

1. Listing Criteria:

- a. UL CCN CYIV.
- b. Non-Environmental Characteristics: UL 50.
- c. Environmental Characteristics: UL 50E.

2. Standard Features:

- a. Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
- b. Degree of Protection: Type 4X.

D. UL CYIV - Outdoor Sheet Metal Cutout Boxes

1. Listing Criteria:

- a. UL CCN CYIV.
- b. Non-Environmental Characteristics: UL 50.
- c. Environmental Characteristics: UL 50E.

2. Standard Features:

- a. Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
- b. Degree of Protection: Type 4X.

2.3 TERMINATION BOXES

- A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.
- B. UL XCKT - Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment :
 - 1. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
 - 2. Standard Features:
 - a. Listed and labeled for installation on line side of service equipment.
 - b. Indoor Degree of Protection: Type 1
 - c. Outdoor Degree of Protection: Type 4X.
 - d.
- C. UL XCKT - Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment
 - 1. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
 - 2. Standard Features:
 - a. Listed and labeled for installation on load side of service equipment.
 - b. Indoor Degree of Protection: Type 1
 - c. Outdoor Degree of Protection: Type 4X.

2.4 MISCELLANEOUS ENCLOSURES

- A. UL XCKT or NWIN - Indoor Sheet Metal Miscellaneous Enclosures
 - 1. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773; or UL CCN NWIN, including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
 - 2. Standard Features:

- a. Degree of Protection: Type 1.
- B. UL XCKT or NWIN - Outdoor Sheet Metal Miscellaneous Enclosures <Insert drawing designation>:
 - 1. Listing Criteria:
 - a. UL CCN XCKT; including UL 1773; or UL CCN NWIN, including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E.
 - 2. Standard Features:
 - a. Degree of Protection: Type 4X.

2.5 RACK OR FRAME SYSTEMS

- A. Description: This category covers rack or frame systems that are not complete but include components and assemblies that are intended to power, protect, heat, cool, or otherwise support electrical or electronic equipment that will be installed at a later time.
- B. UL NWIN - 19 Inch Open Equipment Rack :
 - 1. Listing Criteria:
 - a. UL CCN NWIN; including UL 2416.
 - b. Non-Environmental Characteristics: UL 50.
 - c. Environmental Characteristics: UL 50E or UL 2416.
 - 2. Standard Features:
 - a. Threaded rails designed for mounting telecommunications equipment.
 - b. Width: Compatible with EIA/ECIA 310-E, 19 inch (482.6 mm) equipment mounting with an opening of 17.72 inch (450 mm) between rails.
 - c. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - d. Finish: Manufacturer's standard, baked-polyester powder coat.
 - e. Cable Management:
 - 1) Metal, with integral wire retaining fingers.
 - 2) Baked-polyester powder coat finish.
 - 3) Vertical cable management panels have front and rear channels with covers.
 - 4) Horizontal crossover cable manager at top of each relay rack, with minimum height of two rack units each.
 - f. Configuration: four post.
 - g. Material: Extruded aluminum.
 - 3. Other Available Features Required by the Project:
 - a. Color: Black
 - b. Floor-Mounted Racks:

- 1) Overall Height: As indicated on Drawings .
 - 2) Overall Depth: As indicated on Drawings.
 - 3) Rail Depth: 3 inch (76.2 mm)
 - 4) Four-Post Load Rating: 1000 lb (454 kg).
 - 5) Number of Rack Units per Rack: As indicated on Drawings.
 - a) Numbering: Every rack unit(s), on interior of rack.
 - 6) Threads: 10-32.
 - 7) Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
 - 8) Base must have minimum four mounting holes for permanent attachment to floor.
 - 9) Top must have provisions for attaching to cable tray or ceiling.
 - 10) Self-leveling.
- c. Wall-Mounted Racks:
- 1) Height: As indicated on Drawings .
 - 2) Depth: As indicated on Drawings.
 - 3) Load Rating: 200 lb (91 kg).
 - 4) Number of Rack Units per Rack: As indicated on Drawings.
 - 5) Threads: 10-32.
 - 6) Wall Attachment: Four pre-punched mounting holes.
 - 7) Equipment Access: Integral swing.

2.6 ENCLOSURE-MOUNTED POWER DISTRIBUTION

PART 3 - EXECUTION

3.1 SELECTION OF ELECTRICAL CABINETS AND ENCLOSURES

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of electrical cabinets and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
1. Outdoors:
 - a. Type 4X unless otherwise indicated.
 - b. Locations Subject to Potential Flooding: Type 6P.
 2. Indoors:
 - a. Type 1 unless otherwise indicated.
 - b. Damp or Dusty Locations: Type 12 .
 - c. Locations Exposed to Spraying Oil or Coolants: Type 13.

3.2 INSTALLATION OF ELECTRICAL CABINETS AND ENCLOSURES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Communications Work: BICSI N1.
 - 5. Work in ITE Rooms: NFPA 75.
 - 6. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 7. Cabinets and Cutout Boxes: Article 312 of NFPA 70.
 - 8. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Mount cabinets and enclosures 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 top of box unless otherwise indicated.
 - 2. Do not install cabinets, enclosures, or fittings in contact with concrete or earth.
 - 3. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
 - 4. Identification: Provide labels for cabinets, enclosures, racks and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - c. Label each cabinet, enclosure, and rack with engraved metal or laminated-plastic nameplate.
- D. Interfaces with Other Work:
 - 1. Firestop penetrations of rated walls and partitions.
 - 2. Ground and bond RBBs in cabinets, enclosures, and racks.
 - 3. Apply arc-flash hazard warning labels cabinets, enclosures, and racks.

3.3 FIELD QUALITY CONTROL OF ELECTRICAL CABINETS AND ENCLOSURES

- A. Adminstrant for Electrical Power Tests and Inspections:
 - 1. [Owner] [Tenant] will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections[with assistance of factory-authorized service representative].

- B. Administrant for Communications Tests and Inspections:
 - 1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- C. Field tests and inspections must be witnessed by Architect.
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
- E. Nonconforming Work:
 - 1. Cabinet, enclosure, or rack will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

- A. Remove construction dust and debris from cabinets, enclosures, and racks.

3.5 PROTECTION

- A. Protect coatings and finishes of cabinets, enclosures, and racks 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 262716

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Receptacles with arc-fault and ground-fault protective devices.
5. Locking receptacles.
6. Special-purpose power outlet assemblies.
7. Connectors, cords, and plugs.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 013100 "Project Management and Coordination" for preinstallation conference procedures.
5. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
6. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
8. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.
9. Section 260936 "Modular Dimming Controls" for multiscene and multipreset dimming controls.
10. Section 260943.16 "Addressable Luminaire Lighting Controls" for network lighting control solid-state devices.
11. Section 260943.23 "Relay-Based Lighting Controls" for network lighting control relay devices.
12. Section 262726.11 "General-Use Switches, Dimmer Switches, and Fan-Speed Controller Switches" for additional wiring device products.
13. Section 262726.31 "General-Grade Single Straight-Blade Receptacles" for additional wiring device products.
14. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for additional wiring device products.
15. Section 262726.39 "Locking Receptacles" for additional wiring device products.
16. Section 262726.51 "Connectors, Cords, and Plugs" for additional wiring device products.

1.2 DEFINITIONS

- A. AFCI: Arc-Fault Circuit Interrupter.
- B. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.
- C. GFCI: Ground-Fault Circuit Interrupter.
- D. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site with videoconference option .

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.
 - 2. Include manufacturer's sample extended warranty language.
- B. Samples:
 - 1. One for each kind of toggle switch and cover plate accessory specified, in each finish and color specified.
 - 2. One for each kind of key lock switch and cover plate accessory specified, in each finish and color specified.
 - 3. One for each kind of momentary-contact switch and cover plate accessory specified, in each finish and color specified.
 - 4. One for each kind of rocker switch and cover plate accessory specified, in each finish and color specified.
 - 5. One for each kind of single straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
 - 6. One for each kind of duplex straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
 - 7. One for each kind of receptacle with GFCI device and cover plate accessory specified, in each finish and color specified.

8. One for each kind of locking receptacle and cover plate accessory specified, in each finish and color specified.
9. One for each kind of pin-and-sleeve receptacle specified, in each finish and color specified.
10. One for each kind of cord connector specified, in each finish and color specified.

C. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.6 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra stock material.

B. Special tools.

1.8 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures, conduct tests of complex equipment, analyze test and equipment data, plan a job, and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must possess active NICET EPT Technician IV certification.

1.9 WARRANTY FOR DEVICES

- A. Special Installer Extended Warranty: Installer warrants that installed devices perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must be conveyed to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.
 - 1. Initial Extended Warranty Period: Three years from date of Substantial Completion; [full] [prorated] coverage for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: Eight years from date of Substantial Completion; full coverage for materials only, free on board origin, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Approved Manufacturers:
 - 1. Hubbel
 - 2. Leviton
 - 3. Legrand
 - 4. Eaton

2.2 GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

- A. Toggle Switch:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: UL CCN WMUZ and UL 20.
 - 3. Standard Features:
 - a. Device Color: As indicated on architectural Drawings.
 - b. Configuration:
 - 1) General-duty, 120-277 V, 20 A, poles as indicated on plans.
 - 4. Accessories:

- a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Toggle Switch with Forked Key Lock :
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: UL CCN WMUZ and UL 20.
 - 3. Standard Features:
 - a. Device Color: As indicated on architectural Drawings.
 - b. Configuration:
 - 1) 120-277 V, 20 A, poles as indicated on the drawings. .

2.3 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

- A. Single Straight-Blade Receptacle :
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - 2. Standard Features:
 - a. Device Color White.
 - b. Configuration:
 - 1) General-duty, smooth face, NEMA 6-20R.
 - 2) General-duty, NEMA 14-30R UPS Power
 - 3)
 - 3. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 - 4. Accessories:
 - a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

- A. Duplex Straight-Blade Receptacle :
 - 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 - 2. Standard Features:
 - a. Device Color: As indicated on architectural Drawings.
 - b. Configuration:
 - 1) Heavy-duty, NEMA 5-20R.
 - 2) Heavy-duty, smooth face, NEMA 5-20R.
 - 3. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 - 4. Accessories:
 - a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. Tamper-Resistant Duplex Straight-Blade Receptacle :
- 1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 - b. Surge Protective Devices: UL 1449, Type 3.
 - 2. Standard Features:
 - a. Device Color: As indicated on architectural Drawings.
 - b. Configuration:
 - 1) Heavy-duty, NEMA 5-20R.
 - 2) Heavy-duty, smooth face, NEMA 5-20R.
 - 3. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
 - 4. Accessories:
 - a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.5 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

- A. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device (WP):

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacle GFCIs: UL CCN KCXS, UL 498, and UL 943.
2. Standard Features:
 - a. Device Color: Gray.
 - b. Configuration: Heavy-duty NEMA 5-20R.
3. Other Available Features Required by the Project:
 - a. Has factory-terminated connectors on wiring device pigtails for quick installation.
4. Accessories:
 - a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.6 LOCKING RECEPTACLES

- A. UL RTRT - NEMA, 250 V, Locking Receptacle :
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
 3. Standard Features:
 - a. Device Color: Black with blue voltage indication on face.
 - b. Configuration:
 - c.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receptacles:
 1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.
- B. Cord Reels:

1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GFCI RECEPTACLES

- A. Healthcare Facilities: Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

3.3 INSTALLATION OF SWITCHES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Life Safety and Means of Egress Work: NFPA 101.
 4. Wiring Devices: NECA NEIS 130.
 5. Mounting Heights: NECA NEIS 1.
 6. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:
 1. Identification:
 - a. Identify cover or cover plate for device with panelboard identification and circuit number.
 - b. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.4 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 4. Work in ITE Rooms: NFPA 75.

5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
6. Work in Confined Spaces: NFPA 350.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 - a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
11. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.5 INSTALLATION OF LOCKING RECEPTACLES

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Safety: NFPA 70E.
 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 4. Work in ITE Rooms: NFPA 75.
 5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 6. Work in Confined Spaces: NFPA 350.
 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
 9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 11. Consult Architect for resolution of conflicting requirements.
- C. Interfaces with Other Work:

1. Identification: Provide labels for receptacles and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
 - 1) Identify cover or cover plate for device with panelboard identification and circuit number.
 - 2) Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.6 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
 2. Electrical Maintenance: NFPA 70B.
 3. Electrical Safety: NFPA 70E.
 4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 5. Work in ITE Rooms: NFPA 75.
 6. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
 7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 8. Consult Architect for resolution of conflicting requirements.

3.7 FIELD QUALITY CONTROL OF SWITCHES

- A. Administrant for Electrical Power Tests and Inspections:
 1. Administer and perform tests and inspections
- B. Acceptance Testing Preparation:
 1. **<Insert requirements>.**
- C. Field tests and inspections must be witnessed by Architect
- D. Tests and Inspections:
- E. Nonconforming Work:
 1. Unit will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

- G. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.8 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

- A. Administrant for Electrical Power Tests and Inspections:
 - 1. Administer and perform tests and inspections
- B. Field tests and inspections must be witnessed by **Architect** .
- C. Tests and Inspections:
 - 1. Insert and remove test plug to verify that device is securely mounted.
 - 2. Verify polarity of hot and neutral pins.
 - 3. Measure line voltage.
 - 4. Measure percent voltage drop.
 - 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 - 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
 - 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.
- D. Nonconforming Work:
 - 1. Device will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.9 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

- A. Administrant for Low-Voltage Electrical Tests and Inspections:
 - 1. Administer and perform tests and inspections
- B. Field tests and inspections must be witnessed by Architect .
- C. Tests and Inspections:
 - 1. Insert and remove test plug to verify that device is securely mounted.
 - 2. Verify polarity of hot and neutral pins.
 - 3. Measure line voltage.
 - 4. Measure percent voltage drop.
 - 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 - 6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.
- D. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- F. Manufacturer Services: Engage factory-authorized service representative to [support] [supervise] field tests and inspections.
1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.10 FIELD QUALITY CONTROL OF CONNECTORS, CORDS, AND PLUGS

- A. Administrant for Electrical Power Tests and Inspections:
1. Administer and perform tests and inspections
- B. Nonconforming Work:
1. Unit will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.11 PROTECTION

- A. Devices:
1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
 2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- B. Cord Reels and Fittings:
1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- C. Connectors, Cords, and Plugs:
1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. GFEP: Ground-fault circuit-interrupter for equipment protection.
- B. GFLS: Ground-fault circuit-interrupter for life safety.
- C. SPDT: Single pole, double throw.

1.3 ACTION SUBMITTALS

A. Product Data:

1. 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.
2. Enclosure types and details for types other than UL 50E, Type 1.
3. Current and voltage ratings.
4. Short-circuit current ratings (interrupting and withstand, as appropriate).
5. Include evidence of qualified electrical testing laboratory listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
7. 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] [and] <Insert calculation program format> electronic format.

- B. Shop Drawings: For enclosed switches and circuit breakers.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Include wiring diagrams for power, signal, and control wiring.
- C. Field Quality-Control Submittals:
 - 1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: Furnish to Owner spare parts, for repairing enclosed switches and circuit breakers, that are packaged with protective covering for storage on-site and identified with labels describing contents. [**Include the following:**]
 - 1. Fuses: Equal to [10] <Insert number> percent of quantity installed for each size and type, but no fewer than [three] <Insert number> of each size and type.
 - 2. Fuse Pullers: [Two] <Insert number> for each size and type.
 - 3. <Insert spare parts>.

1.7 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: [Two] <Insert number> years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: [Three] <Insert number> years from date of Substantial Completion; [full] [prorated] coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain products from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- D. Approved Manufacturers:
 - 1. Eaton
 - 2. Schnieder Electric
 - 3. Siemens
 - 4. GE/ABB
 - 5. Hubbel

2.2 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty:
 - 1. Singlethrow.
 - 2. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate **[specified] [indicated]** fuses.
 - 3. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- B. 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. Service-Rated Switches: Labeled for use as service equipment.
 - 5. Lugs: Compression type, suitable for number, size, and conductor material.

2.3 NONFUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Three Pole, Single Throw, 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.
- B. 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. Lugs: Compression type, suitable for number, size, and conductor material.

2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Circuit breakers must be constructed using glass-reinforced insulating material. Current carrying components must be completely isolated from handle and accessory mounting area.
- B. Circuit breakers must have toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. Circuit-breaker handle must be over center, be trip free, and reside in tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon must be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with push-to-trip button, located on face of circuit breaker to mechanically operate circuit-breaker tripping mechanism for maintenance and testing purposes.
- C. Maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings must be clearly marked on face of circuit breaker. Circuit breakers must be **[100 percent rated] [series rated] [100 percent rated or series rated as indicated on Drawings]. [Circuit breaker/circuit breaker] [Fuse/circuit breaker]** combinations for series connected interrupting ratings must be listed by UL as recognized component combinations. Series rated combination used must be marked on end-use equipment along with statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."
- D. MCCBs must be equipped with device for locking in isolated position.
- E. Lugs must be suitable for 75 deg C rated wire.
- F. Standard: Comply with UL 489 with required interrupting capacity for available fault currents.
- G. 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.
- H. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- I. 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.
- J. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

- K. 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.
- L. GFLS Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6 mA trip).
- M. GFEP Circuit Breakers: With Class B ground-fault protection (30 mA trip).
- N. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 4. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
 - 5. 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.
 - 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 7. Zone-Selective Interlocking: Integral with electronic ground-fault trip unit; for interlocking ground-fault protection function.
 - 8. Electrical Operator: Provide remote control for on, off, and reset operations.

2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, UL 50E, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: Enclosure must be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel, NEMA Type as indicated on Drawings.
- C. Conduit Entry: UL 50E Types 4, 4X, and 12 enclosures may not contain knockouts. UL 50E Types 7 and 9 enclosures must be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: Circuit-breaker operating handle must be externally operable with operating mechanism being integral part of box, not cover. Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.
- E. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.
- F. UL 50E Type 7/9 enclosures must be furnished with 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 will indicate Installer's acceptance of areas and conditions as satisfactory.

3.2 SELECTION OF ENCLOSURES

- A. Indoor, Dry and Clean Locations: UL 50E, Type 1 .
- B. Outdoor Locations: UL 50E, Type 4X .
- C. Other Wet or Damp, Indoor Locations: UL 50E, Type 4
- D. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 12.

3.3 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
 - 1. 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.
 - 2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
 - 3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 4. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
 - 5. Install fuses in fusible devices.

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. Field tests and inspections must be witnessed by Architect .
- 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 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. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use low-resistance ohmmeter.
 - a) 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 lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
 - h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on Drawings.
 - i. Verify correct phase barrier installation.
 - j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
 - 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - b. Measure contact resistance across each switchblade fuseholder. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
 - d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

- e. Perform ground fault test in accordance with NETA ATS Section 7.14 "Ground Fault Protection Systems, Low-Voltage."
- 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 Drawings.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify that unit is clean.
 - e. Operate circuit breaker to ensure smooth operation.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use low-resistance ohmmeter.
 - a) 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 lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
 - g. Inspect operating mechanism, contacts, and chutes in unsealed units.
 - h. Perform adjustments for final protective device settings in accordance with coordination study.
 - 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
 - c. Perform contact/pole resistance test. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
 - d. Perform insulation resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid state

components, follow manufacturer's recommendation. Insulation resistance values may be no less than 2 M Ω .

e. Determine the following by primary current injection:

- 1) Long-time pickup and delay. Pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
- 2) Short-time pickup and delay. Short-time pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
- 3) Ground-fault pickup and time delay. Ground-fault pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
- 4) Instantaneous pickup. Instantaneous pickup values must be as specified and within manufacturer's published tolerances.

f. Test functionality of trip unit by means of primary current injection. Pickup values and trip characteristics must be as specified and within manufacturer's published tolerances.

g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset trip logs and indicators. Investigate units that do not function as designed.

i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Test and adjust controls, remote monitoring, and safeties.

D. Nonconforming Work:

1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Collect, assemble, and submit 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.

F. Manufacturer Services:

1. Engage factory-authorized service representative to **[support]** **[supervise]** field tests and inspections.

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. After installation, protect enclosed switches and circuit breakers from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- A. Infrared Scanning of Enclosed Switches and Breakers: Two months after Substantial Completion, perform infrared scan of joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
 - 1. Instruments and Equipment: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Follow-up Infrared Scanning: Perform two follow-up infrared scans of enclosed switches and breakers, one at four months and another at 11 months after Substantial Completion.
 - 3. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
 - 4. Report: Prepare certified report that identifies units checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 262816

SECTION 263213.13 - DIESEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diesel-engine-driven generator sets.
2. Diesel engine.
3. Diesel fuel-oil system.
4. Control and monitoring.
5. Generator overcurrent and fault protection.
6. Generator, exciter, and voltage regulator.
7. Load bank.
8. Outdoor engine generator enclosure.
9. Remote radiator motors.
10. Vibration isolation devices.

B. Related Requirements:

1. Section 262313 "Paralleling Low-Voltage Switchgear" for controls and paralleling equipment for large or multiple parallel engine generators.
2. Section 263343 "Battery Chargers" for remote engine battery chargers.
3. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

- A. EPS: Emergency power supply.
- B. EPSS: Emergency power supply system.
- C. 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.

1.3 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 (liters 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 (cubic meters per minute) at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F (35, 27, 21, and 10 deg C). 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.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer, and testing agency.

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, including full fuel tank, supplied enclosure, subbase-mounted fuel tank, 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.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

- E. Warranty: For special warranty.

1.5 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.

1.6 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: 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.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 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: <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DIESEL-ENGINE-DRIVEN GENERATOR SETS

- A. Acceptable Manufacturers:

1. MTU/Rolls-Royce
2. Kohler/Rehiko
3. Cummins

- 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.
 3. Comply with NFPA 99.
 4. Comply with NFPA 110 requirements for Level 1EPSS.
- D. UL Compliance: Comply with UL 2200.
- E. Engine Exhaust Emissions: Comply with EPA Tier [2] [3] [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 (Minus 15 to plus 40 deg C).
 2. Relative Humidity: Zero to 100 percent.
 3. Altitude: Sea level to 1000 feet (300 m)
- H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:
1. High salt-dust content in the air due to sea-spray evaporation

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: Standby.
- D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.
- E. EPSS Class: Engine generator shall be classified as a Class 48 according to NFPA 110.
- F. Service Load: As indicated on Plans.
- G. Power Factor: 0.8 lagging.
- H. Frequency: 60 Hz.
- I. Voltage: As indicated on Drawings.
- J. Phase: As indicated on Drawings.
- K. Governor: Adjustable isochronous, with speed sensing.
- L. 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.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.
- M. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
 - 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- N. 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:

O. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. 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.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time:

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 and with NFPA 110 requirements for Level 1 equipment for heater capacity.
- E. Integral 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.
 - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- F. Muffler/Silencer:
 - 1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 25 dB at 500 Hz.
 - b. Sound level measured at a distance of 25 feet (8 m) 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: As required by NFPA 110 for system level specified.

4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times 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 (10 deg C) 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] [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 (minus 40 to plus 60 deg C) 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 37.
- 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: Minimum 133 percent of total fuel required for planned operation 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. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. 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.
- C. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.
- D. Comply with UL 508A.
- E. Configuration:
1. 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.
 2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
 3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:
 - a. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.
 - b. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards." Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 - c. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."

F. 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.
 - f. AC ammeter, for each phase.
 - g. AC frequency meter.
 - h. Generator-voltage adjusting rheostat.
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 prealarm.
 - 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 for the indicated EPSS class
 - 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. EPS load indicator.
 - t. Battery high-voltage alarm.
 - u. Low cranking voltage alarm.
 - v. Battery-charger malfunction alarm.
 - w. Battery low-voltage alarm.
 - x. Lamp test.
 - y. Contacts for local and remote common alarm.
 - z. Low-starting air pressure alarm.
 - aa. Low-starting hydraulic pressure alarm.
 - bb. Remote manual stop shutdown device.
 - cc. Air shutdown damper alarm when used.

- dd. Air shutdown damper shutdown device when used.
 - ee. Generator overcurrent-protective-device not-closed alarm.
 - ff. Hours of operation.
 - gg. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.
- G. 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 same protocol as BAS. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."
- H. 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.
- I. 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 prealarm.
 - 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. Low-cranking voltage alarm.
 - 19. Generator overcurrent-protective-device not-closed alarm.
- J. 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.
- K. 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.
 - 1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
 - 2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Overcurrent Protective Device:
 - 1. Molded-case circuit breaker, thermal-magnetic type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristic: Designed specifically for generator protection.
 - b. Trip Rating: Matched to generator output rating.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 - 2. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 - 3. Insulated-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to, or integrated with, control and monitoring panel.
 - 4. Molded-case type disconnect switch; 100 percent rated:
 - a. Trip Rating: Matched to generator output rating.
 - b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.
- C. 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.
- D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.
1. Indicate ground fault with other engine generator alarm indications.
 2. Trip generator protective device on ground fault.

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: NEMA 4X.
- H. Instrument Transformers: Mounted within generator enclosure.
- I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110
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 percent on one step, full load.
 3. Provide anti-hunt provision to stabilize voltage.
 4. Maintain frequency within 5 percent and stabilize at rated frequency within 5 seconds.
- J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

- L. Subtransient Reactance: 12 > percent, maximum.

2.9 LOAD BANK

- A. Description:
 - 1. Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive unit capable of providing a balanced three-phase, delta-connected load to engine generator at 100percent rated-system capacity, at 80 percent power factor, lagging. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
 - 2.
- B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.
- C. Reactive Load Elements: Epoxy-encapsulated reactor coils.
- D. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
- E. Load-Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
- F. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
- G. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge. Components other than resistive elements shall receive exterior epoxy coating with compatible primer. Comply with requirements in Section 099600 "High-Performance Coatings."
- H. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
- I. Load-Bank Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.

- J. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

2.10 OUTDOOR ENGINE GENERATOR ENCLOSURE

- A. Description:
 - 1. Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to 150 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.
 - a. Sound Attenuation Level: Level 2.
 - 2. Prefabricated or pre-engineered, galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure; erected on concrete foundation.
- B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 150 mph
- C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Fire Protection: Provide fire protection according to Section 211000 "Water-Based Fire-Suppression Systems." Provide smoke detector in enclosure; mounted according to NFPA 72.
- E. Hinged Doors: With padlocking provisions.
- F. Space Heater: Thermostatically controlled and sized to prevent condensation.
- G. Lighting: Provide weather-resistant LED lighting with 30 fc (330 lx) average maintained.
- H. 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.
- I. Muffler Location: Within enclosure.
- J. 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.
 - 3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.
- K. Interior Lights with Switch: Factory-wired, vapor-proof 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.

- L. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

2.11 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: Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
 - 2. Shore A Scale Durometer Rating: 50 .
 - 3. Number of Layers: Two >.
 - 4. Minimum Deflection: 1 inch (25 mm) .
- 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- (6-mm-) 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 (25 mm) .
- 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.

2.12 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.13 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 and with NFPA 110, Level 1 Energy Converters.

- 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.
 9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 10. Report factory test results within 10 days of completion of test.

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 PREPARATION

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
1. Notify Architect, Construction Manager, and Owner no fewer than five working days in advance of proposed interruption of electrical service.
 2. Do not proceed with interruption of electrical service without Owner's written permission.

3.3 INSTALLATION

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.
- 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 restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) 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."
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. 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."
- F. 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.
 3. Test fuel prior to first startup for water, particulate content, and other contaminants.
- G. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- 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." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.
- D. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. 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 (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
 - b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
 - 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. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
 - 3. 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.
 - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - 5. 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.
 - 6. Exhaust Emissions Test: Comply with applicable government test criteria.
 - 7. 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.
 - 8. 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.
 - 9. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. 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.
- E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and retest as specified above.
- I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
- J. 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.
- K. 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.

3.7 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.

3.8 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 263213.13

SECTION 263343 - BATTERY CHARGERS

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 battery chargers for emergency engine generators.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of battery charger.
 - 1. Include system overview, construction details, material descriptions, and dimensions of battery charging and monitoring systems.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, performance specifications, and furnished accessories.
- B. Shop Drawings: For battery chargers.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field installation, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Include instructions for Installer.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer.
- B. Seismic Qualification Data: Certificates, for battery chargers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Include Certificate of Compliance for nonstructural components and systems. Withstand certification is for below-grade, grade, and roof-level installations, installations in essential facilities, and for life-safety applications, based on actual shake-testing. Certified installation locations shall include mounting directly to structural wall and directly to nonstructural wall.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For battery chargers to include in operation and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's operating specifications and user's guides.
 - b. Data sheet for each battery charger with nameplate information and performance specifications.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide certification that manufacturer complies with requirements of ISO 9001.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of battery chargers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 1236 for Category BBHH. OEM-supplied, open-frame chargers may be UL recognized to Category BBHH provided they are housed in a listed enclosure.
- C. NFPA Compliance: Comply with NFPA 110.
- D. Environmental Conditions: Battery charger shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 40 to plus 158 deg F (minus 40 to plus 70 deg C) with full charger output available up to 104 deg F (40 deg C).
 - 2. Relative Humidity: 5 to 100 percent.
 - 3. Altitude: Meets full performance from sea level to 5000 feet (1600 m). Chargers installed at higher altitudes may automatically derate output power to prevent overheating of internal components, but shall remain operable.
 - 4. Electromagnetic Immunity: Charger power terminals shall be immune to conducted and radiated electromagnetic energy to IEC 61000-4-12.
 - 5. Vibration Resistance: Charger enclosure rated to IEC 60068-2-6 vibration test; 4-g force from 18 to 500 Hz on 3 axes; and 0.01 power spectral density value from 20 to 500 Hz.

- E. Seismic Performance: Battery chargers shall withstand the effects of earthquake motions determined according to FBC 2023.
 - 1. Shake-Table Testing: 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**]."
 - 3. Component Importance Factor: 1.5.
 - 4. Equipment seismic application, spectral response acceleration, short period (Sds) for Project is indicated on Drawing
- F. Battery-Charger Power Conversion Energy Efficiency:
 - 1. Comply with Florida Department of Energy standards for appliance energy efficiency.

2.2 BATTERY CHARGERS FOR EMERGENCY ENGINE GENERATORS

- A. Source Limitations: Obtain battery chargers from same manufacturer as generator set, or from a single manufacturer recommended by generator manufacturer.
- B. Battery-Charger Operation: Current-limited, constant-voltage, automatic-boost type charger designed for lead-acid batteries, with the following features:
 - 1. Automatic Boost Mode: Operates in boost charging mode after battery discharge. Boost duration automatically adjusted depending on the following:
 - a. Differing depths of battery discharge.
 - b. Differing relationships of battery amp-hour capacity to charger ampere output.
 - c. Differing parasitic direct current loads.
 - 2. Output Voltage Regulation: Charger regulates output to within plus or minus 0.5 percent of manufacturer-provided voltage settings despite variations of input voltage, input frequency, and output current.
 - 3. Battery Thermal Compensation: Battery temperature compensation with adjustable slope, factory set at minus 0.18 percent per degree C, and equipped for sensing battery temperature. Include battery temperature sensor mounted on battery negative terminal.
 - 4. Automatic Dead Battery Recharge: Charger automatically recharges a battery discharged to 0 V at full-rated output current, without the need for user intervention.
 - 5. AC Input: Charger operates from any 47- to 63-Hz ac source with voltage ranging from 90- to 265-V rms.
 - 6. Lead-Acid Battery Longevity and Safety Mode: Charger emulates vehicle duty for which starting batteries are designed to maximize battery life, minimize battery explosion risk, and minimize electrolyte loss in lead-acid batteries:
 - a. Boost Mode Recharge: After recharge is complete in boost mode, charger reverts to a voltage just above battery open-circuit voltage, for the majority of battery-charger operating hours, when fully charged. The charger remains in operation to prevent battery discharge.
 - b. Float Mode: Charger periodically elevates output voltage to ensure a fully charged battery, charger then returns to just above battery nominal voltage. Charger repeats this cycle until the next battery discharge, when the battery shall be recharged in the boost mode.

7. Charger Enclosure: NEMA 250, Type 4X (IP67), wall mounted and rated for generator duty with charger enclosure vibration resistance. Housing materials: aluminum or stainless steel.
- C. Battery-Charger Status Indication and Alarms:
1. Output Voltage and Current: Digital or analog meters on front panel, or by conveying performance data to generator control panel via J-1939 datalink. Accuracy: Plus 2 percent for voltage and plus 5 percent for current.
 2. Alarm Outputs: **[Individual Form C contacts] [Single summary Form C contact]**, or by conveying alarms to generator control panel via J-1939 datalink.
 - a. AC voltage failure.
 - b. Low dc voltage.
 - c. High dc voltage.
 - d. Low cranking voltage.

2.3 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate battery-charger fabricator's quality-control and testing methods.
- B. Testing: Test and inspect battery chargers according to UL 1236 for Category BBHH recharge performance.
- C. Factory Tests: Test and inspect assembled battery chargers to manufacturer's written instructions. Verify NFPA 110 recharge performance by validating that battery charger is listed to UL 1236 Category BBHH on the UL certification database.
- D. Battery charger will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, mounting locations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting battery-charger performance.
- B. Examine roughing-in for conduit systems and electrical connections to verify actual locations of connections before battery-charger installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BATTERY-CHARGER INSTALLATION

- A. Follow manufacturer's written instructions to prevent damage from static electricity. Provide clearances for service and ventilation.

- B. Battery chargers are configured at the factory. If settings need to be field-configured, follow manufacturer's setup written instructions.
- C. Coordinate jumper datalinks with emergency generator control panel capabilities.

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." Provide branch-circuit overcurrent protection.
- C. Comply with requirements for branch-circuit protection and service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."

3.4 IDENTIFICATION

- A. Identify system components according to 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. Battery charger will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain battery chargers and related equipment.
- B. Coordinate this training with that for emergency engine generator equipment.

END OF SECTION 263343

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Molded-case-type automatic transfer switches.
 - 2. Transfer switch accessories.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Molded-case-type automatic transfer switches.
 - 2. Transfer switch accessories.
- B. Product Data Submittals: For each 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.
- C. 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.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- 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.

1.4 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.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications:
 - 1. Member company of NETA.
 - a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
 - 1. Notify Architect, Construction Manager, and Owner no fewer than five working days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Owner's written permission.

1.7 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: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with NFPA 99.

- D. Comply with NFPA 110.
- E. Comply with UL 1008 unless requirements of these Specifications are stricter.
- F. 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.
- G. 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 30 cycles.
- H. 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.
- I. 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.
- J. 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.
- K. 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 and alternative buses.
 - 7. Service Disconnecting Means: Externally operated, manual electrically actuated.
- L. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- M. Neutral Terminal: Solid and fully rated unless otherwise indicated.
- N. 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.
- O. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- P. Battery Charger: For generator starting batteries.
 - 1. Float type, rated 10 A.

2. Ammeter to display charging current.
 3. Fused ac inputs and dc outputs.
- Q. 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.
- R. 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 front access.
- S. Enclosures: General-purpose NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Acceptable Manufacturers:
1. ASCO Power Products
 2. Siemens
 3. Eaton
 4. Others recommended by Generator Vendor by Prior Approval.
- 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 or Hard-drawn copper, 98 percent conductivity.
 6. Main and Neutral Lugs: Compression type.
 7. Ground Lugs and Bus-Configured Terminators: Compression type.
 8. Ground bar.
 9. Connectors shall be marked for conductor size and type according to UL 1008.
- 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. 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.
- F. 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.
- G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- H. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.
- I. 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:
 - a. Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
 - b. 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.
 - 12. 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.

J. 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 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. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.
 - 1. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."
- G. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."
- H. 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.
- I. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."
- J. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

- A. Administrant for Tests and Inspections:
 - 1. Engage qualified testing agency to administer and perform tests and inspections.
 - 2.
- B. Tests and Inspections:
 - 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. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
 - g. 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 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Lightning protection system for ordinary structures.
- B. Section Includes: Lightning protection system for the following:
 - 1. Ordinary structures.

1.2 ACTION SUBMITTALS

- A. Product Data: For each product.
- B. Shop Drawings:
 - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
 - 2. Include raceway locations needed for the installation of conductors.
 - 3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
 - 4. Include roof attachment details, coordinated with roof installation.
 - 5. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Lightning protection cabling attachments to roofing systems and accessories.
 - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
 - 3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
- B. Qualification Data: For Installer.
- C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
- D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
 - b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.
- B. Completion Certificate:
 1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: **UL-listed installer, category OWAY.**

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION FOR STRUCTURES

2.2 PERFORMANCE REQUIREMENTS

- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.
- B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.
- C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

- A. Air Terminals:
 1. Copper unless otherwise indicated.
 2. Threaded base support.
- B. Air Terminal Bracing:
 1. Copper.
 2. 1/4-inch (6-mm) diameter rod.
- C. Class I Main Conductors:
 1. Stranded Copper: 57,400 circular mils in diameter.
- D. Secondary Conductors:
 1. Stranded Copper: 26,240 circular mils in diameter.

- E. Ground Loop Conductor: Stranded copper.
- F. Ground Rods:
 - 1. Material: Copper-clad steel.
 - 2. Diameter: 3/4 inch (19 mm).
- G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A .
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.
- C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A
 - 1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
 - 2. Install conduit where necessary to comply with conductor concealment requirements.
 - 3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: **exothermic weld**
- C. 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.

3.3 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
 - 1. Perform inspections as required to obtain a UL Master Label for system.
- B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 264313 - SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 surge protective devices (SPDs).
2. Type 2 surge protective devices (SPDs).
3. Enclosures.
4. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
4. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
5. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

1.2 DEFINITIONS

- A. I_n : Nominal discharge current.
- B. Maximum Continuous Operating Voltage (MCOV): The maximum designated RMS value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.
- C. Metal-Oxide Varistor (MOV): An electronic component with a significant bidirectional, nonlinear current-voltage characteristic.
- D. Mode(s), Modes of Protection, or Protection Modes: Electrical paths where the SPD offers defense against transient overvoltages. Examples include: line to neutral (L-N), line to ground (L-G), line to line (L-L), and neutral to ground (N-G).
- E. SCCR: Short-circuit current rating.
- F. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.
- G. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.
- H. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include electrical characteristics, specialties, and accessories for SPDs.
 - b. Certification of compliance with UL 1449 by qualified electrical testing laboratory recognized by authorities having jurisdiction including the following information:
 - 1) Tested values for VPRs.
 - 2) I_n ratings.
 - 3) MCOV, type designations.
 - 4) OCPD requirements.
 - 5) Manufacturer's model number.
 - 6) System voltage.
 - 7) Modes of protection.
- B. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For manufacturer's special warranty.

1.5 WARRANTY

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.
 - 1. Initial Extended Warranty Period: **[Five]** <Insert number> year(s) from date of Substantial Completion, for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: **[10]** <Insert number> year(s) from date of Substantial Completion, for materials only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

- A. Source Limitations: Obtain devices from single source from single manufacturer.
- B. General Characteristics:
 - 1. Reference Standards: UL 1449, Type 1.
 - 2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.

3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than **240kA**. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V three-phase, four-wire circuits must not exceed the following:
 - a. Line to Neutral: 1200 V for 480Y/277 V.
 - b. Line to Line: 2000 V for 480Y/277 V.
5. SCCR: Not less than 200.
6. I_n Rating: 20 kA.

C. Options:

1. Include integral disconnect switch.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include indicator light display for protection status.
4. Include audible alarm.
5. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V(ac) for remote monitoring of protection status.
6. Include surge counter.

2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Source Limitations: Obtain devices from single source from single manufacturer.

B. General Characteristics:

1. Reference Standards: UL 1449, Type 2; UL 1283.
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 150 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:
 - a. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
 - b. Line to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
 - c. Neutral to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
 - d. Line to Line: 2000 V for 480Y/277 V, 1200 V for 208Y/120 V.
5. SCCR: Equal or exceed 100kA.
6. I_n Rating: 20 kA.

C. Options:

1. Include LED indicator lights for power and protection status.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.

3. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V(ac) for remote monitoring of protection status.
4. Include surge counter.

2.3 TYPE 3, TYPE 4, AND TYPE 5 SURGE PROTECTIVE DEVICES (SPDs)

- A. Type 3, Type 4, and Type 5 SPDs are not approved for field installation. See "Related Requirements" Paragraph in "Summary" Article for products with manufacturer-installed Type 3, Type 4, and Type 5 SPDs.

2.4 ENCLOSURES

- A. Indoor Enclosures: Type 1.
- B. Outdoor Enclosures: Type 4X.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.
- B. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
 2. Do not exceed manufacturer's recommended lead length.
 3. Do not bond neutral and ground.
- C. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections:
 1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
 2. Inspect anchorage, alignment, grounding, and clearances.

3. Verify that electrical wiring installation complies with manufacturer's installation requirements.
- C. Nonconforming Work:
 1. SPDs that do not pass tests and inspections will be considered defective.
 2. Remove and replace defective units and retest.
- D. Prepare test and inspection reports.
- E. Manufacturer Services:
 1. Engage factory-authorized service representative to support field tests and inspections.

3.3 STARTUP SERVICE

- A. Complete startup checks in accordance with manufacturer's instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 264313

SECTION 265000 - LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Luminaires.
2. Luminaire fittings.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables" specifies wiring connections installed by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies channel and angle supports installed by this Section.
6. Section 260546 "Poles for Electrical Systems" specifies lighting standards, utility poles, and accessories referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
8. Section 260923 "Lighting Control Devices" specifies automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors installed by this Section.
9. Section 260936 "Modular Dimming Controls" specifies architectural dimming systems with dimming installed by this Section.
10. Section 260943.16 "Addressable Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" specify manual or programmable control systems with low-voltage control wiring or data communication circuits installed by this Section.

1.2 DEFINITIONS

- A. BUG Rating: Backlight, uplight, and glare rating for light pollution from exterior luminaires.
- B. Correlated Color Temperature (CCT): The absolute temperature (in kelvins) of a blackbody whose chromaticity (color quality) most nearly resembles that of the light source.
- C. Color Rendering Index (CRI): The measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference light source. The lower the CRI of a light source, the more difficult it is to identify colors and stripes on electronic components and wiring.

- D. IDA: International Dark-Sky Association.
- E. IES: Illuminating Engineering Society.
- F. LPD: Lighting power density.

1.3 ACTION SUBMITTALS

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

- 1. Luminaires: Include the following additional information:

- a. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - 1) If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - 2) Listing criteria identified in approval letter must match specified listing criteria. Approval of only equipment's enclosure is not considered approval of equipment for intended application.
 - 3) Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for similar products are not acceptable.
- b. Product Certificates: Include product certificates stating compliance with standards listed below, signed by manufacturer or fabricator.
 - 1) Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with current accreditation under National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
 - 2) Testing Agency Certified Data: For luminaires indicated on Lighting Fixture Schedule on the Drawings, photometric data certified by qualified independent testing laboratory. Photometric data for remaining luminaires must be certified by manufacturer.
 - 3)
- c. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- d. Include operating characteristics, electrical characteristics, and furnished accessories.
- e. Include schedule of submitted lighting products. Arrange schedule and accompanying product data in order by luminaire and lamp designations indicated on the Drawings.
- f. Include battery and charger data for emergency lighting units.
- g. Include ballast factor.
- h. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
- i. Include photometric data and adjustment factors obtained from qualified laboratory tests.
- j. Include manufacturer's sample warranty language.

- 2. Luminaire Fittings: Include the following additional information:

- a. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
 - 1) If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - 2) Listing criteria identified in approval letter must match specified listing criteria. Approval of only equipment's enclosure is not considered approval of equipment for intended application.
 - 3) Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for similar products are not acceptable.
 - b. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - c. Include operating characteristics, electrical characteristics, and furnished accessories.
 - d. Include schedule of submitted lighting products. Arrange schedule and accompanying product data in order by luminaire and lamp designations indicated on the Drawings.
 - e. Include manufacturer's sample warranty language.
- B. Shop Drawings: Prepare and submit the following:
- 1. Drawings, Diagrams, and Supporting Documents for Custom Luminaires:
 - a. Include plans, elevations, sections, and mounting and attachment details.
 - b. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Include diagrams for power, signal, and control wiring.
- C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.

- B. Extra stock material.

1.7 MOCKUPS

- A. Provide mockups as indicated on the Drawings to verify selections made under Sample submittals and to set quality standards for materials and execution.
 - 1. Build mockup of luminaires in room or space, complete with power and control connections.
 - 2. Obtain Architect's approval of mockups before starting installation of related Work on the Project.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
 - 4. Maintain mockups during construction in undisturbed condition as standard for judging the completed Work.
 - 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician IV certification.
- D. Luminaire Photometric Testing Laboratory: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" accredited under NIST HB 150-1, and complying with applicable IES testing standards.
- E. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with applicable IES standards.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect exposed surface finishes on lighting equipment by applying strippable, temporary protective covering before shipping.

1.10 WARRANTY FOR LUMINAIRES

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed luminaires perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 - 1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that luminaires perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Provide luminaires as indicated on Drawing Luminaire Schedule. Where a product or option is not selected, noted, or conflicts with notes elsewhere in Contract Documents, pricing for intermediate not-for-construction issuances shall be for the worst case available. For final construction documents, any discrepancies in schedules not addressed in pre-bid questions shall be rectified at the expense of the contractor. "Discrepancies" include but are not limited to control options, changes in model numbers from Design date to Procurement date,
- C. Substitutions will not be accepted.

2.2 LUMINAIRES

- A. Surface-Mounted Luminaire
 - 1. Source Limitations: Bin LEDs for this luminaire type within 2-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type.
 - 2. Listing Criteria:
 - a. LED Luminaires: UL CCN IFAM; including UL 1598.
 - b. Outdoor Canopy Luminaires: UL CCN IFAW; including UL 1598.
 - c. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
 - 3. Standard Features:
 - a. Openings: Doors, frames, and access panels must operate smoothly, not leak light under operating conditions.
 - 4. Other Available Features Required by the Project:

- a. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM/NOMMA AMP 500 for recommendations for applying and designating finishes.
 - 1) Finish designations prefixed by AA comply with system established by 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, complying with AAMA 611.
 - a) Mechanical Finish: Medium satin.
 - b) Chemical Finish: Etched, medium matte.
 - c) Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker.
 - 4) Class I, Color-Anodic Finish: AA-M32C22A42/A44, complying with AAMA 611.
 - a) Mechanical Finish: Medium satin.
 - b) Chemical Finish: Etched, medium matte.
 - c) Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker).
- b. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM/NOMMA AMP 500 for 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, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2) 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.
 - 3) Color: As selected by Architect from manufacturer's full range.
- c. Visible variations in metal finishes are unacceptable in adjoining components.
- d. Dimmable from 100 percent to zero percent of maximum light output.
- e. EMI Filters: Factory installed to suppress conducted EMI in accordance with MIL-STD-461E. Fabricate luminaires with one filter on each ballast or driver requiring filter.
- f. Stainless steel latches.
- g. Integral pressure equalizer.
- h. Photoelectric Switch: Factory-mounted integral to luminaire; listed and labeled in accordance with UL CCN WJFX, including UL 773, or in accordance with UL CCN WJCT, including UL 773A.
 - 1) Contact Relays: Factory mounted, single throw, designed to fail in on position, and factory set to turn light unit on at 1.5 to 3 fc (15 to 30 lx) and off at 4.5 to 10 fc (45 to 100 lx) with 15 s minimum time delay. Relay must have directional lens in front of photocell to prevent artificial light sources from causing false turn-off.

- a) Relay with locking-type receptacle must comply with NEMA C136.10.
 - b) Adjustable window slide for adjusting on-off set points.
- 5. Installation Markings:
 - a. All Luminaires (UL CCN HYXT):
 - 1) "DRY LOCATIONS ONLY."
 - 2) "SUITABLE FOR DAMP LOCATIONS."
 - 3) "SUITABLE FOR WET LOCATIONS."
 - 4) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 5) "SUITABLE FOR GROUND-MOUNTED RECESSED."
 - 6) "COVERED CEILING MOUNT ONLY."
 - 7) "WALL MOUNT ONLY"
 - 8) "FOR CEILING MOUNTING ONLY."
 - 9) Marked with mounting orientation, such as "THIS END UP."
 - 10) "SUITABLE FOR AIR-HANDLING USE."
 - 11) "VENTILATING OR COOLING AIR ONLY."
 - 12) "ONLY FOR USE IN CEILING PLENUM OF NONCOMBUSTIBLE CONSTRUCTION OR WITH AIR-HANDLING PARTS THAT COVER VENT OPENINGS."
 - 13) "INSTALL ONLY IN ENVIRONMENTAL AIR-HANDLING SPACES WHERE A COMPLETE METAL ENCLOSED WIRING SYSTEM IS PROVIDED."
 - 14) "MIN 90°C SUPPLY CONDUCTORS."
 - 15) "NOT FOR USE IN DWELLING."
 - 16) "SUITABLE FOR USE AS RACEWAY."
 - 17) "60 Hz" or "AC ONLY."
 - 18) Marked to identify voltage supply or type of branch circuit or both.
 - b. LED Luminaires (UL CCN IFAM):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING <Insert ambient temperature>°C."
 - 2) "PUSH CONDUCTORS INTO JUNCTION BOX."
 - 3) "WALL MOUNT ONLY."
 - 4) "NONCOMBUSTIBLE SURFACE ONLY."
 - 5) "SUITABLE FOR UNDER-CABINET MOUNT."
 - 6) "SUITABLE FOR CONTINUOUS ROW MOUNTING."
 - 7) "THIS LUMINAIRE MUST BE MOUNTED OR SUPPORTED INDEPENDENTLY OF AN OUTLET BOX."
 - c. Outdoor Canopy Luminaires (UL CCN IFAW):
 - 1) "CANOPY LUMINAIRE - NOT THERMALLY PROTECTED."
 - 2) "FOR COVERED CEILING MOUNT ONLY."
 - 3) "OPEN CEILING MOUNT ONLY."
- 6. Seismic and Wind Performance: Installed product must perform in accordance with Section 018123 "Facility Seismic and Wind Criteria" and the following:
 - a. Withstand Requirement: Unit must remain in place without separation of parts when subjected to specified criteria during seismic events[**and unit must be fully operational after seismic events**]."
 - b. Component Overstrength Factor (Ω_o): 1.5 >.

B. Recessed Luminaire :

- 1.
2. Source Limitations: Bin LEDs for this luminaire type within 2-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type.
3. Listing Criteria:
 - a. Incandescent Luminaires: UL CCN IEZX; including UL 1598
 - b. LED Luminaires: UL CCN IFAO; including UL 1598
 - c. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
4. Standard Features:
 - a. Ceiling Compatibility: NEMA LE 4.
 - b. Openings: Doors, frames, and access panels must operate smoothly, not leak light under operating conditions.
 - c. .
 - d. LED Luminaires (UL CCN IFAO):
 - 1) Rated Life: 50 000 hours to L70.
5. Installation Markings:
 - a. All Luminaires (UL CCN HYXT):
 - 1) "DRY LOCATIONS ONLY."
 - 2) "SUITABLE FOR DAMP LOCATIONS."
 - 3) "SUITABLE FOR WET LOCATIONS."
 - 4) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 5) "SUITABLE FOR GROUND-MOUNTED RECESSED."
 - 6) "COVERED CEILING MOUNT ONLY."
 - 7) "WALL MOUNT ONLY"
 - 8) "FOR CEILING MOUNTING ONLY."
 - 9) Marked with mounting orientation, such as "THIS END UP."
 - 10) "SUITABLE FOR AIR-HANDLING USE."
 - 11) "VENTILATING OR COOLING AIR ONLY."
 - 12) "ONLY FOR USE IN CEILING PLENUM OF NONCOMBUSTIBLE CONSTRUCTION OR WITH AIR-HANDLING PARTS THAT COVER VENT OPENINGS."
 - 13) "INSTALL ONLY IN ENVIRONMENTAL AIR-HANDLING SPACES WHERE A COMPLETE METAL ENCLOSED WIRING SYSTEM IS PROVIDED."
 - 14) "MIN [75°C] [90°C] [150°C] [200°C] [250°C] SUPPLY CONDUCTORS."
 - 15) "NOT FOR USE IN DWELLING."
 - 16) "SUITABLE FOR USE AS RACEWAY."
 - 17) "60 Hz" or "AC ONLY."
 - 18) Marked to identify voltage supply or type of branch circuit, or both.
 - b. LED Luminaires (UL CCN IFAO):
 - 1) "TYPE IC LUMINAIRE."
 - 2) "TYPE NON-IC LUMINAIRE."
 - 3) "INHERENTLY PROTECTED LUMINAIRE."

- 4) "INSTALL IN BUILDINGS OF FIRE-RESISTANT CONSTRUCTION."
- 5) "INSTALL WITH MINIMUM SPACINGS BETWEEN A) CENTER-TO-CENTER OF ADJACENT LUMINAIRES: <Insert distance> INCHES; B) TOP OF LUMINAIRE AND AN OVERHEAD BUILDING MEMBER: <Insert distance> INCHES; AND C) LUMINAIRE CENTER-TO-SIDE OF BUILDING MEMBER: <Insert distance> INCHES."
- 6) "FOR USE IN CONCRETE ONLY."
- 7) "SUITABLE FOR USE IN POURED CONCRETE."
- 8) "SUITABLE FOR SUSPENDED CEILING."
- 9) "SUITABLE FOR GROUND-MOUNTED RECESSED ONLY."
- 10) "SUITABLE FOR GROUND-MOUNTED RECESSED."
- 11) "BLINKING LIGHT OF THIS THERMALLY PROTECTED LUMINAIRE MAY INDICATE OVERHEATING."
- 12) "ACCESS ABOVE CEILING REQUIRED."
- 13) "ACCESS BEHIND WALL REQUIRED."
- 14) "FOR USE IN ONE- AND TWO-FAMILY DWELLINGS ONLY."
- 15) "FOR USE IN NON-FIRE-RATED INSTALLATIONS."
- 16) Provide correlating markings identifying matching housing, trim, rough-in section, and finishing section.
- 17) "Chicago Electrical Code" or "CCEA."

C. UL FWBO - Exit Fixture :

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria:
 - a. Exit Fixtures: UL CCN FWBO; including UL 924, NFPA 101[, **NFPA 5000**], and ICC IBC.
 - b. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
3. Standard Features:
 - a. Light Source: LED; 50,000 hours minimum rated life.
 - b. Legend Color: Green.
 - c. Internal emergency power unit.
 - d. Battery Type: Li-ion.
4. Installation Markings:
 - a. All Luminaires (UL CCN HYXT):
 - 1) "SUITABLE FOR DAMP LOCATIONS."
 - 2) "SUITABLE FOR WET LOCATIONS."
 - 3) "SUITABLE FOR MOUNTING WITHIN 1.2 M (4 FT) OF THE GROUND" or "SUITABLE FOR FLOOR PROXIMITY INSTALLATION."
 - 4) Marked to identify voltage supply or type of branch circuit or both.
 - b. Exit Fixtures (UL CCN FWBO):
 - 1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING xx °C."

2.3 LUMINAIRE FITTINGS

A. Luminaire Support Accessories:

1. Standard Features:

- a. Sized and rated for luminaire weight.
- b. Capable of maintaining luminaire position after cleaning and relamping.
- c. Capable of supporting luminaire without causing deflection of ceiling or wall.
- d. Capable of supporting horizontal force equal to 100 percent of luminaire weight and vertical force equal to 400 percent of luminaire weight.

2. Other Available Features Required by the Project:

- a. Hook Hangers: Integrated assembly matched to luminaire, supply voltage, and equipment with threaded attachment, cord, and locking-type plug.
- b. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm) wire supports adjustable to 10 ft (3 m) in length.
- c. Aircraft Cables: 5/32 inch (4 mm) diameter aircraft cable supports adjustable to at least 10 ft (3 m) in length.
- d. Single-Stem Hangers: 1/2 inch (13 mm) nominal diameter steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- e. Rod Hangers: 3/16 inch (5 mm) nominal diameter, cadmium-plated, threaded steel rod.

2.4 MAINTENANCE MATERIAL ITEMS

A. Spare Parts: Furnish to Owner spare parts, for repairing lighting equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

1. Diffusers and Lenses: One for every 100 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.
3. LED Drivers: One for every 100 of each type and rating installed. Furnish at least one of each type.

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 PREPARATION

- A. Temporary Lighting: If approved by Architect, specified luminaires for the Project may be installed for temporary lighting. Install and energize minimum quantity of luminaires necessary to meet needs of construction activities. When construction is sufficiently complete, remove, disassemble, clean, and relamp luminaires used for temporary lighting before reinstalling for the Project's delivery.

3.3 SELECTION OF LUMINAIRES

- A. Selection of Luminaires shall be in accordance with Luminaire Schedule.

3.4 INSTALLATION OF LIGHTING

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 3. Work in Confined Spaces: NFPA 350.
 - 4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 5. Installation of Indoor Lighting Systems: NECA NEIS 500.
 - 6. Installation of Exterior Lighting Systems: NECA NEIS 501.
 - 7. Installation of Industrial Lighting Systems: NECA NEIS 502.
 - 8. Installation of Luminaires, Lampholders, and Lamps: Article 410 of NFPA 70.
 - 9. Installation of Extra-Low-Voltage Lighting: Article 411 of NFPA 70.
 - 10. Installation of Lighting for Sensitive Electronic Equipment: Article 647 of NFPA 70.
 - 11. Installation of Emergency Lighting and Exit Signs: ICC IBC, NFPA 101, and Parts IV and V in Article 700 of NFPA 70.
 - 12. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Install luminaires level, plumb, and square with finished floor or grade unless otherwise indicated.
 - 2. Install luminaires at height and aiming angle as indicated on the Drawings.
 - 3. Coordinate layout and installation of luminaires with other construction.
 - 4. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
 - 5. Exterior Bollard Luminaires:
 - a. Align units for optimum directional alignment of light distribution.
 - b. Install on concrete base with top 4 inch (100 mm) **<Insert dimension>** above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

6. Exterior In-Ground Luminaires:
 - a. Install on concrete base with top 4 inch (100 mm)> 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."
7. Exterior Corrosion Prevention:
 - a. Do not use aluminum in contact with earth or concrete. When in direct contact with dissimilar metals, protect aluminum with insulating fittings or treatment.
 - b. When embedding steel conduits in concrete, wrap conduit with 10 mil (0.254 mm) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
8. Flush-Mounted Luminaire Support:
 - a. Secured to outlet box.
 - b. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
 - c. Trim ring flush with finished surface.
9. Wall-Mounted Luminaire Support: Attached to structural members in walls
 - a. Do not attach luminaires directly to gypsum board.
10. Suspended Luminaire Support:
 - a. Ceiling Mount:
 - 1) Hook hangers.
 - 2) Twowires.
 - 3) Four aircraft cables.
 - b. Pendants and Rods: Where longer than 48 inch (1220 mm), brace to limit swinging.
 - c. 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.
 - d. Continuous Rows of Luminaires: Provide tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
 - e. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
11. Ceiling-Grid-Mounted Luminaire Support:
 - a. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inch (150 mm) from luminaire corners.
 - b. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for application.
 - c. Luminaires of Sizes Smaller than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently

- with no fewer than two 3/4 inch (20 mm) metal channels spanning and secured to ceiling tees.
- d. Seismic Restraint: Install at least one independent support rod or wire from structure to tab on luminaire. Wire or rod must have breaking strength for luminaire weight with safety factor of 3.0.
- 12. Remote Mounting of Ballasts or Drivers: Do not exceed distance between ballast or driver and luminaire recommended by ballast or driver manufacturer.
- 13. Emergency Power Units: Secure with approved fasteners in four or more locations, spaced near corners of unit.
- 14. Install wiring connections for luminaires.
- 15. Identification: Provide labels for luminaires and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - c. Label each enclosure with engraved metal or laminated-plastic nameplate.
- D. Systems Integration: Integrate lighting control devices and equipment with electrical power connections for operation of luminaires as specified.

3.5 FIELD QUALITY CONTROL OF LIGHTING

- A. Administrant for Electrical Power Tests and Inspections:
 - 1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- B. Administrant for Field Tests and Inspections of Lighting Installations:
 - 1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- C. Field tests and inspections must be witnessed by Architect .
- D. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 3. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
 - 4. Verify operation of photoelectric controls.
 - 5. Exterior Illumination Tests:
 - a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards.
- E. Nonconforming Work:
 - 1. Luminaire will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.

- F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- G. Manufacturer Services: Engage factory-authorized service representative to **[support]** **[supervise]** field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project's site.

3.6 SYSTEM STARTUP

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 - 2. Burn-in lamps that require specific aging period to operate properly, prior to occupancy by Owner.
 - 3. Charge emergency power units and batteries] minimum of one hour and depress switch to conduct short-duration test.
- B. Manufacturer Services: Engage factory-authorized service representative to supervise system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project's site.

3.7 ADJUSTING

- A. Luminaire Aiming Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aiming direction of luminaires to suit occupied conditions. Make up to two visits to the Project's site during other-than-normal hours for this purpose. Some of the 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 must be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust aim of luminaires in presence of Architect.

3.8 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain luminaires **[and photoelectric controls]**.
 - 2. Provide video recordings of training sessions to Owner

3.9 PROTECTION

- A. After installation, protect lighting equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 265000

SECTION 270500 – COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This section of the project specifications pertains to and addresses scope and performance requirements for all division 27 specifications sections.
- B. For each element of the information transport system listed below, the contractor shall provide all services, labor, equipment, supplies, materials and appurtenances for the complete installation and commissioning of a fully operational system per the drawings and the project manual. The information transport system includes but is not limited to:
 - 1. Grounding and Bonding
 - 2. Pathways
 - 3. Hangers and Supports
 - 4. Cable Trays
 - 5. Underground Pathways and Structures
 - 6. Sleeves and Sleeve Seals
 - 7. Identification Systems
 - 8. Equipment Room Fittings
 - 9. Racks Frames and Enclosures
 - 10. Backbone Cabling
 - 11. Horizontal Cabling
- C. Purpose and Scope
 - 1. Whether expressed or implied all work is included. Any item not specifically indicated, but necessary for a complete, operational system shall be provided.
 - 2. Indications or reasonable implications of articles, materials, means or methods related to execution of the work that are prescribed, means execution of each such item of work shall be included.
 - 3. Omission of a device, component or assembly from the specifications does not indicate that it is not to be provided if it is necessary for a complete operational system based on the entirety of the specifications and industry standard or convention.
 - 4. Language that denotes singularity or plurality shall not be used to limit the provision of scope as is necessary for a complete system.
 - 5. Refer to dimensioned architectural/structural drawings for locations of equipment, building elements and devices.
 - 6. Field verification of measurements takes priority over dimensioned drawings.
 - 7. The contractor shall accommodate movement of a device up to 10 feet from the location indicated on the drawings without additional cost up to and until rough in is complete.

1.2 SCOPE AND RESPONSIBILITY

- A. Provide full-time on-site field representation for Division 27 scope of work once site work has commenced.

- B. Include detailed scheduling information for Information Transport System installation and testing in the construction schedule. Provide detailed construction schedule information including but not limited to:
 - 1. Notice to Proceed
 - 2. Design
 - 3. Shop drawings
 - 4. Electrical Work
 - 5. Fabrication
 - 6. Equipment installation
 - 7. Testing, commissioning, and training.
- C. Submit schedule information as soon as possible but no later than 2 calendar weeks after NTP. The schedule durations shall be such that the overall project milestones in the project manual are maintained.
- D. Equipment rooms and closets associated with information transport systems shall be finished, cleaned and temperature controlled as soon as possible to facilitate completion of wiring and terminations. Space shall be free of dust and dirt prior to installation of any Equipment. The Architect shall determine that the condition of these rooms is acceptable prior to the installation of any equipment in the space.
- E. Attend contractor coordination meetings and make other trades and contractors aware of critical path elements of construction. Coordinate work of this trade with other trades and contractors including but not limited to electrical and mechanical.
- F. Provide a complete pathway system including back boxes, junction boxes, mortar boxes, conduit and cable tray for the information transport systems.
- G. Conduit from telecommunications outlets shall extend to the cable tray or J hooks.
- H. Provide Telecommunications Grounding System as shown on the drawings and specified herein.
- I. Furnish and install all devices, equipment, and appurtenances resulting in complete, functional, and fully operational systems as specified herein, indicated on the drawings and listed below:
 - 1. Section 270526 – Grounding and Bonding for Communications Systems
 - 2. Section 270528 – Pathways for Communications Systems
 - 3. Section 270528.29 – Hangers and Supports for Communications Systems
 - 4. Section 270536 – Cable Trays for Communications Systems
 - 5. Section 270544 – Sleeves and Sleeve Seals for Underground Communications Pathways and Cabling
 - 6. Section 270553 – Identification for Communications Systems
 - 7. Section 271100 – Communications Equipment Room Fittings
 - 8. Section 271323 – Communications Optical Fiber Backbone Cabling
 - 9. Section 271500 – Communications Copper Horizontal Cabling
- J. Contractor shall provide commissioning of the information transport system. Contractor shall submit test data from all copper and fiber testing. Contractor shall provide the owner/user with the manufacturer's certificate of warranty for the commissioned system.

1.3 RELATED DOCUMENTS

- A. General

1. Information relative to this scope of work is included elsewhere in the drawings and specifications. The contractor and all subcontractors and suppliers are responsible for the content of the entire project documents package.

B. Reference Specifications, Standards, and/or Codes

1. Permitting and fees is the responsibility of the contractor.
2. NFPA, NEC and IBC shall govern all work.
3. All work shall conform to all Federal, State and local ordinances.
4. Where applicable, all fixtures, equipment and materials shall be as approved or listed by the following:
 - a. Factory Mutual Laboratories (FM).
 - b. Underwriters Laboratories, Inc. (UL).
 - c. National Electrical Manufacturers Association (NEMA).
5. Where design drawings and specifications are above the minimum code requirements, the drawings and specifications shall govern.

1.4 ALL WORK SHALL MEET OR EXCEED THE STANDARD AND PROCEDURES OF THE FOLLOWING:

A. American National Standards Institute (ANSI/EIA/TIA)

1. 568-D.0 Generic Telecommunications Cabling for Customer Premise
2. 568-D.1 Commercial Building Telecommunications Cabling Standard
3. 568-D.2 Balanced Twisted Pair Telecommunications Cabling and Component Standard
4. 568-D.3 Optical Fiber Cabling Components Standard.
5. 569-E Commercial Building Standard for Telecommunications Pathways and Spaces
6. 598-C Commercial Building Standard for Telecommunications Optical Fiber Cable Color Coding.
7. 606-D Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
8. 607-D Commercial Buildings Grounding (Earthing) and Bonding Requirements for Telecommunications
9. 758-C Customer Owned Outside Plant Telecommunications Cabling Standard.

B. All work shall meet or exceed the standards set forth in the following:

1. National Electrical Manufacturers Association (NEMA)
2. American Society of Testing Materials (ASTM)
3. Institute of Electronic & Electrical Engineers (IEEE)
4. Americans With Disabilities Act (ADA)

C. Include all items of labor and material required to comply with such standards and codes. Where quantity, sizes or other requirements indicated on the drawings or herein specified are in excess of the standard or code requirements, the specifications or drawings, respectively, shall govern.

D. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of the current local codes and any additional authorities having jurisdiction.

1.5 QUALITY ASSURANCE

A. General

1. All personnel performing any installation, configuration, or oversight of the communications infrastructure systems' implementation shall hold the appropriate certifications, training, and experience requirements as specified in this section. In no instance shall any contractor's staff perform any work on the communications infrastructure without the appropriate training and certifications.
2. The Architect reserves the right to reject any installation staff member which meets the stated minimum requirements but in the opinion of the Architect does not meet the Architects and industry standards of satisfactory workmanship.
3. Installation Contractors shall have been in business a minimum of five (5) years performing similar work as described within these specifications.
4. All equipment and components will be new product unused, without defect.
5. All similar equipment shall be a product of a single manufacturer.

B. Backbone Cabling Installer Minimum Qualifications:

1. All installers shall be manufacturer certified for FO installation and termination. Contractor shall have at least one person assigned, and directly involved in the installation. Proof of certification shall be presented for approval of qualifications.
2. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program shall be developed and overseen by an RCDD. Construction submittal drawings shall be stamped by the RCDD.
3. System installer shall own or have immediate access to test and splice equipment (OTDR, power meter, light source, mechanical splice kit and fusion splicer) in order to install, restore, and test fiber optic systems properly. All test equipment shall be certified within dates set by a certified calibration certificate for each piece of test equipment used to verify fiber readings to be included with final documentation.
4. Installation personnel shall be certified by Manufacturer on all fiber connectors and other equipment utilized in this project.

C. Horizontal Cabling Installer Minimum Qualifications:

1. The Contractor shall be fully capable of installing cabling of low voltage infrastructure to support applications such as, but not limited to data, voice and imaging network systems.
2. Installation personnel shall be certified by Manufacturer on all horizontal connectors and other equipment utilized in this project.

D. Active Networking Equipment Installer Minimum Qualifications:

1. Contractor Qualifications: The Contractor shall be fully capable of installing and configuring the local area network infrastructure. The Contractor shall at a minimum possess the following qualifications:
 - a. Installing contractor shall possess the appropriate certifications and/or training from the proposed manufacturer(s) for service the equipment and software and supporting evidence of those qualifications.
2. The Contractor shall provide manufacturer certified and trained network engineers through the manufacturer's Professional Services division(s) to assist in the network deployment including configuring, installing, and testing of the equipment. The resources provided through the manufacturer's Professional Services will coordinate through the supervision of the Architect to complete the network deployment as detailed in the project specifications and drawings.

1.6 SUBMITTALS

A. Bill of Materials

1. Provide a bill of materials for all major components, accessories, and hardware to be provided in order to assemble a complete functioning system.
2. Bill of materials shall include-
 - a. Manufacturer Name
 - b. Model
 - c. Version
 - d. Quantity

B. Provide shop drawings electronically or in accordance with division 1.

C. Product Submittal

1. Submittal must consist of a complete package, the submittal shall include the following:
2. A Title Page complete with the following required information:
 - a. Project name.
 - b. Date.
 - c. Name of Architect.
 - d. Name of Construction Manager
 - e. Name Electrical Contractor
 - f. Name General Contractor
 - g. Name Subcontractors.
3. An Index Page complete with the following required information:
 - a. Name of the Supplier.
 - b. Name of the Manufacturer.
 - c. Title, section and paragraph of the Specification Sections. (Example section 271500, paragraph 2.4)
 - d. Products in order as specified in PART II of the related specification.
4. Each Data Sheet shall have the specific reference to the Specification it is to be used for, noting the section and paragraph.
5. Product Data showing multiple products, models or options shall be clearly marked identifying the specific product, model and options, which are submitted for review. Unmarked submittals or facsimile copies shall not be acceptable.
6. Submit product data for all equipment showing:
 - a. Product performance, mechanical and electrical specifications.
 - b. Manufacturer's installation instructions.
 - c. Certification from the submitted manufacturers that the Contractor's designated personnel are trained on the installation of the system. Include Contractor installer's name, experience and responsibility.
 - d. Product test compliance certificates if required.

D. Bid Submittals

1. The following minimum qualification evidence shall be submitted as part of the Contractor/Subcontractor bid proposal for review and approval by the Architect. All submittals shall conform to the requirements identified in Division 1:

E. Shop Drawings

1. Submittals consisting of reproduced copies of the original bidding documents will be rejected. The contractor is required to develop a complete set of drawings specific to the final configuration of the system based on the manufacturer and models of all components included. Shop drawings are to include all changes noted in addenda, as well as any changes included in architect's special instructions or change orders issued prior to the submittal of the shop drawings.
2. Shop drawings shall be submitted with product data.
3. All drawings shall be created using an industry recognized computer aided design program. Recognized programs include AutoDesk Revit, AutoCAD, and Microstation. All drawings are to be made using one of the last 3 software releases available.
4. Submit shop drawings for all equipment showing:
 - a. Location and type of all field equipment on floor plans.
 - 1) Telecommunications Outlets of All Types
 - 2) Telecommunication Rooms
 - 3) Equipment Rooms
 - 4) Display Locations
 - 5) Active Headend Equipment
 - b. Large scale (minimum 1/4"=1') floor plan and elevation view drawings of all telecommunications closets depicting all racks, consoles, cabinets, equipment, outlets, etc.
 - c. Size and spacing of all anchors, wall penetrations, joinery construction, etc., required for complete system installation.
 - d. Electrical riser diagrams identifying all signal, power, and ground circuitry.
 - e. Elevations of all equipment racks showing equipment mounting locations (front and rear if any equipment is rear mounted).
 - f. Wall elevations showing mounting of cabinets, and wall mount hardware and electronics.
 - g. Wire management details for the installation of cable harnesses inside racks, equipment cabinets and other areas of exposed cable.
 - h. Block diagrams depicting wire connectivity to all data closets.
 - i. Wiring diagrams for all equipment and devices (active and passive).
 - 1) Wiring diagrams are required to show point to point connection of all terminations for all devices.
 - 2) Indicate wire type used for connection.
 - 3) Indicated type of termination to be made.
 - j. Equipment room layout, relay rack elevations and fiber management panel layout drawings
 - k. Equipment room layout and fiber management panel layout drawings
 - l. Information transport system grounding and bonding system

F. Samples

1. Provide samples as requested for review and approval of substitutions or as specified in Division 27 specifications.

G. Training Plan

1. Submit a training plan for all systems for approval.
2. As a minimum, the plan submitted must include individualized training paths for the following personnel on all aspects of the information transport system.
 - a. Administrators
 - b. Supervisors
 - c. Operators
 - d. Maintenance Personnel
3. As a minimum, the plan submitted must include the following:
 - a. Proposed classes or sessions.
 - b. Recommended attendees for each class or session.
 - c. Proposed class or session objectives.
 - d. Proposed class or session agenda and duration.
 - e. Proposed supporting materials for each class or session.
 - f. Proposed testing procedure for evaluation purposes.
 - g. Proposed documentation of testing and evaluation.

H. Operating and Maintenance Data

1. Provide operating and maintenance manual for all Division 27 systems and equipment.
2. The O & M manuals shall be cross-referenced to the Record Documents and contain the following information for all systems:
 - a. Product catalog cut sheets and specifications of all equipment.
 - b. Operational description of all equipment and performance features in each system using clear and understandable terminology.
 - c. Detailed programming instructions for all systems and all software programs.
 - d. Troubleshooting procedures to diagnose malfunctions in each system.
 - e. Repair procedures for all equipment.
 - f. Preventative maintenance procedures for all equipment.
 - g. Table listing the model numbers for all equipment in each system including the names and phone numbers of the manufacturer and their representative directly responsible for this project.

I. Record Documents

1. Submit an electronic copy of the "As-built" condition of all systems including:
 - a. A set of updated shop drawings showing all Contract changes.
 - b. A set of updated product data showing all Contract changes.
 - c. Floor plan showing conduit raceway routing including all equipment rack, rack configuration, cabinets, cabinet configurations, pull box locations, and conduit sizes.
 - d. Complete point-to-point wiring diagrams showing equipment, devices, wire and cable (Signal, power and ground). This document shall also include all terminal block designations, abbreviations and color-coding.

2. Provide report showing results of all tests required and outlined in individual 27 05 00 series specifications.
3. Training session(s) shall be provided digitally recorded via digital download link and one (1) USB drive.
4. Transmittal letter listing delivery of complete spare parts inventory.
5. Copy of warranty certificate.
6. Procedures for addressing warranty/repair issues.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Products that have been in manufacture for at least one year, unless otherwise specified by performance requirements.

2.2 SUBSTITUTIONS

- A. Deviations from specifications
 1. Changes to the scope of work in the bid proposal are not acceptable.
 2. Any proposed equipment substitution must be submitted 10 calendar days prior to the bid date. Accompany the request, the Contractor must provide manufacturers product specifications for the exact model be substituted. This literature must clearly state all specifications called for in the bidding documents, as well as performance characteristics not specified but inherent to the product listed in the specifications. Any items approved as a substitute will be listed by addendum prior to the bid opening. Substitutions after the award of bid will only be allowed in case of discontinued equipment, or if an item of equal or better quality is available and will not affect the contract cost of the system.
 3. Changes to the general provisions are not acceptable. Any proposed change is to be submitted to the Architect for review. Any approved changes will be listed by addendum prior to the bid opening.
 4. When a specified item is found to be discontinued or obsolete by the manufacturer, the contractor is required to substitute the manufacturer recommended equivalent for that product. If an equivalent is not available, the contractor is instructed to notify the Architect in writing prior to bid time.
- B. Where specific products are sole source specified, no substitutions will be allowed.

2.3 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are readily available.
- B. All factory wiring shall be identified on or provided with the equipment being furnished and on all wiring diagrams and included with O & M manuals.
- C. When factory testing is specified
 1. The Architect shall have the option of witnessing factory tests. The Contractor shall notify the Architect a minimum of 21 calendar days prior to the manufacturers making the factory tests.
 2. When equipment fails to meet factory test and reinspection is required, the Contractor shall be liable for all additional expenses.

2.4 EQUIPMENT IDENTIFICATION

PART 3 - EXECUTION

3.1 INSPECTION

- A. Before installing equipment, carefully inspect the installed Work of all other Trades. Verify that all such Work is complete to the point where the installation of electronic equipment may properly commence. Verify that the telecommunications closets are free of airborne contaminants prior to the installation of electronic equipment.
- B. Verify that all equipment is installed in accordance with all pertinent codes and regulations, the original design, and the referenced standards.
- C. In the event of discrepancy, immediately notify the Architect.
- D. Do not proceed with installation in areas of discrepancy until such discrepancies have been fully resolved.
- E. Return to original new condition any work disturbed during system installation.

3.2 INSTALLATION

- A. Install all equipment in strict accordance with the manufacturer's recommendations, reviewed shop drawings, BICSI TDMM latest edition, and EIA/TIA Standards for balanced twisted pair and fiber optic cable.
- B. Secure equipment with fasteners suitable for the use, materials, and loads encountered. If requested, submit evidence proving suitability. Do not attach electrical materials to roof decking, removable or knockout panels, or temporary walls and partitions.
- C. To the extent possible all conduits shall be embedded in walls and concealed above ceilings. Where conduit must be surface mounted and where it is less than 12' AFF in inmate accessible areas, provide GRS conduit and secure it in place using two-hole straps with security Torx fasteners.
- D. Working spaces shall be not less than specified in the National Electrical Code for all voltages specified.
- E. Where the Architect determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled as directed at no additional cost to the Owner/User. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, pumps, belt guards, transformers, piping, and duct work.

3.3 WORK PERFORMANCE

- A. Coordinate location of equipment with other trades to minimize interferences.
- B. Holes through concrete and masonry in new and existing structures shall be cut with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills shall not be allowed, except where permitted by the Architect as required by limited working space.
- C. Holes shall not affect structural sections such as ribs or beams.

- D. Holes shall be laid out in advance. The Architect shall be advised prior to drilling through structural sections for determination of proper layout.
- E. Any holes created in walls, floors, or ceilings by the Contractor are to be sealed with a fire rated caulking according to all national, state, and local codes and this project manual.
- F. Hangers and other supports shall support only equipment and materials. Provide not less than a safety factor of 5, which shall conform to any specific requirements in the Construction Documents.
- G. The Contractor is responsible for repairing and or replacing any damage caused by their workforce at no additional cost to the Owner/User, or the Owner/User's representatives.

3.4 PROTECTION AND CLEANING OF SYSTEMS AND EQUIPMENT

- A. Protect all materials and equipment from damage during storage at the Site and throughout the construction period. Equipment and materials shall be protected during shipment and storage against physical damage, dirt, moisture, cold and rain.
- B. Prevent damage from rain, dirt, sun, and ground water by storing equipment on elevated supports and covering all sides with securely fastened protective rigid or flexible waterproof coverings.
- C. Protect piping by storing it on elevated supports and capping the ends with suitable closure material to prevent dirt accumulation in the piping.
- D. During construction, cap the top of all conduits and raceway installed vertically.
- E. During installation, protect equipment against entry of foreign matter on the inside, and vacuum clean both inside and outside before testing and operating.
- F. Damaged equipment, as determined by the Architect, shall be replaced.
- G. Protect painted surfaces with removable heavy kraft paper, sheet vinyl or equal, installed at the factory and removed prior to final inspection.
- H. Repaint damaged "FINISH" paint on equipment and materials with painting equipment and finished with same quality of paint and workmanship as used by the original manufacturer so repaired areas are not obvious.
- I. Conduit back boxes, floor boxes, and poke thru's shall be vacuumed clean prior to the installation of cable.

3.5 LABELING

- A. Comply with the requirements within specification 27 05 53 "Identifications for Communications Systems"

3.6 CABLE TERMINATIONS AND DRESS

- A. Installation of communication conductors shall adhere to the following:
 - 1. Furnish and install cable supports as specified.
 - 2. All cables and/or conductors shall be terminated with approved cable termination connectors compatible with the specific termination.

3. Label all cables on both ends and on all patch panel/termination points.
4. Cables shall be neatly bundled using latch and hook type straps.

3.7 CLEANING

- A. Daily during construction and prior to Owner/User acceptance of the building, remove from the premises and dispose of all packing material and debris caused by work performed under Division 27 specifications.
- B. Remove all dust and debris from interiors and exteriors of electrical equipment. Clean accessible current carrying elements prior to being energized.
- C. Upon completion of the work, remove excess debris, materials, equipment, apparatus, tools and the like and leave the premises clean, neat, and orderly.

3.8 TESTING AND VERIFICATION

- A. General
 1. The installation of all communications infrastructure components shall be fully tested and inspected prior to acceptance by the architect. The following provides the general approach to testing, inspection, and acceptance.
 2. Communications Field verification services shall be required in a timely manner for the purpose of acceptance of the installation.
 3. All cable test results must use the permanent affixed label for the test's identification name/number.
- B. Testing
 1. Must be supervised on-site by a BICSI RCDD. Must demonstrate knowledge and compliance with all BICSI, TIA/EIA, UL, and NEC standards and codes.
 2. All members of the Contractor's team must be certified by the manufacturer as having completed the necessary training to complete their part of the field verification. Resumes of the entire team shall be provided along with documentation of completed training courses.
- C. Field Verification Reports
 1. After each inspection and test, the Contractor shall promptly submit 2 copies of field verification report to the architect.
 2. Each report shall include:
 - a. Date Issued.
 - b. Project Title and number.
 - c. Project Phase of Testing
 - d. Field Verification Contractor name, address, and telephone number.
 - e. Name of inspector and job number.
 - f. Date and time of sampling or inspection.
 - g. Record of temperature and weather conditions.
 - h. Date of test.
 - i. Identification of specification section.
 - j. Location of test in the Project.
 - k. Cable ID where applicable.
 - l. Type of inspection or test.
 - m. Results of tests and compliance with Contract Documents.

- n. Interpretation of test results.
- 3. Provide raw test device data files with test report submission.
- 4. Provide a summary spreadsheet of all test results that list each cable tested and the result. Organize spreadsheet by communications room.
- D. Contractor's Responsibilities
 - 1. Provide incidental labor and facilities to provide access to work to be tested, to facilitate tests and inspections, and for storage of test equipment.
 - 2. Notify the Architect (1) calendar week prior to expected time for operations requiring inspection and testing services.
 - a. When tests or inspections cannot be performed after such notice, the Contractor shall notify the Architect.
 - 3. Provide permanent link testing on all installed cables.
 - 4. Provide channel testing through entire channel for all circuits that are cross-connected and patched to end-devices.
- E. Code Compliance Testing
 - 1. Inspections and tests required by codes or ordinances, or by a plan approval authority having jurisdiction over the project site, and which are made by a legally constituted authority, shall be the responsibility of and shall be paid for by the Contractor, unless otherwise provided in the Contract Documents.

3.9 TESTING OF CATEGORY 6 CABLING

- A. The Category 6 UTP cable runs shall be tested for full compliance with TIA/EIA 568-D.1 and D.2, Category 6 specifications and construction documents. Testing shall be performed with an ISO/IEC 61935-1 Level IIIe test set at a minimum. Testing shall be performed as outlined in TSB-95, TSB-155-A, and ANSI/TIA/EIA 568D specifications and shall include length, wire map, shield continuity, characteristic impedance, attenuation, propagation delay, delay skew, return loss, Near-End Crosstalk (NEXT), Far-End Crosstalk (FEXT), Attenuation to Crosstalk Ratio, Far-end (ACR-F), Power Sum Attenuation to Crosstalk Ratio, Far – End (PS ACR-F), and Attenuation to Crosstalk Ratio – Near End (ACR-N). The entire channel shall pass TSB-155-A, and ANSI/TIA/EIA 568D.2 requirements. Any pairs not meeting the requirements of the standard shall be brought into compliance by the Contractor at no charge to the project. Complete end to end (including patch cords) test results must be submitted to the Architect for all circuits that will have end-devices connected. Complete channel tests shall not be required for circuits that will not have end-devices connected. Permanent link testing shall be performed for all installed cabling links and results submitted for review and approval.

- B. Electrical Characteristics:

Mutual Capacitance	5.6 nF/100 at 1 KHz				
Characteristic Impedance	100	MHz:	100	±	15 ohms;
			250	MHz:	100 ± 22 ohms;
				MHz:	100 ± 32 ohms
DC Resistance Max	9.38 Ohms/100m				
Positive ACR	Out to 500 MHz-km				

- C. All Category 6 UTP cables shall meet or exceed the following cabling specifications for ISO/IEC 11801-2.1 for Class E (TIA/EIA Category 6 UTP):

Freq (MHz)	Insertion Loss (dB) Min.	PS-NEXT (dB) Min.	PS ACR-N (dB) Min.	PS-ACR-F (dB) Min.	PS AACR-F	Return Loss
100	20.9	37.1	16.2	20.3	37.0	12.0
200	30.1	31.9	1.8	14.2	31.0	9.0
300	37.4	28.8	-8.6	10.7	27.5	7.2
400	43.7	26.6	-17.1	8.2	25.0	6.0
500	49.3	24.8	-24.5	6.3	23.0	6.0

3.10 Fiber Optic Testing

- A. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing. An Architect representative shall have the option to witness all field tests.
- B. Factory Test: Prior to shipment of the FO cable, 100 percent of the fibers shall be tested with an optical time domain reflectometer at 850/1300 nm for multimode fiber and 1310/1550 nm for single-mode fiber. The optical time domain reflectometer shall be calibrated to show anomalies of 0.2 dB as a minimum. All information and supporting data of factory testing for each strand of fiber shall be furnished to the Architect as support documentation for before and after installation data.
- C. Field Test: The Contractor shall verify the complete operation of any provided data transmission equipment during the field testing. Tests shall be performed on 100 percent of the fibers of each circuit and repeated from the opposite end of each circuit. Field tests shall include as a minimum:
- After termination and bulkhead mounting, each terminated fiber is to be tested for end-to-end (including patch chord) loss with a power meter/light source. Power attenuation test shall be performed in the 850 nm and 1300 nm for multimode or 1310 nm and 1550 nm for single mode wavelength band of the transmitter to be used on the circuit being tested. The flux shall be measured at the Fiber-Optic (FO) receiver end and shall be compared to the flux injected at the transmitter end. There shall be a jumper added at each end of the circuit under test so that end connector loss shall be validated. Rotational optimization of the connectors will not be permitted. The circuit loss shall not exceed the calculated circuit loss by more than 1 dB.

3.11 FIBER TESTING SPECIFICATION

- A. All fiber cables will be tested in accordance with the latest version of the QC Fiber Optics Testing SOP and Corning Cable Systems' NPI EWP-74 documentation. All backbone and horizontal cabling, which is terminated by the Contractor, shall be tested. Compliance with the latest version of Corning Cable Systems NPI EWP-74 will satisfy all EIA/TIA Standards.
- B. The insertion loss for each mated fiber optic connector pair shall be $\leq$ 0.75 dB. Reflectance for single-mode single fiber UPC cable assemblies shall be $\leq$ -55 dB. Mated connector pair loss testing shall be based on one unidirectional OTDR inspection in accordance with the OTDR operating manual for systems greater than 300 feet.
- C. In addition to connector insertion loss for each mated pair, the Contractor shall perform end-to-end insertion loss testing for each multimode fiber at 850 nm and 1300 nm from one direction for each terminated fiber span in accordance with TIA-526-14-B (OFSTP 14) and single-mode fibers at 1310 nm and 1550 nm from one direction for each terminated fiber span in accordance with TIA-526-7

(OFSTP 7). For spans greater than 90 meters, each tested span must test to a value less than or equal to the value determined by calculating a link loss budget. For horizontal spans less than or equal to 90 meters, each tested span must be < 2.0 dB.

- D. Inspect each terminated multimode fiber span for continuity and anomalies with an OTDR at 1300 nm from one direction in accordance with the OTDR operating manual for systems greater than 300 feet. Inspect each terminated single-mode fiber span for continuity and anomalies with an OTDR at 1550 nm from one direction in accordance with OTDR operating manual for systems greater than 300 feet.
- E. Test fiber strands for Optical Return Loss (ORL). All fibers must conform to Corning Cable Systems internal specification to ensure that any fiber reflections present have an ORL > 60 dB.

3.12 SPECIALTY CABLE TESTING

- A. All specialty type cables that are specific to a given system (e.g., coaxial cabling, security cabling, elevator traveler cabling) shall be tested in accordance with manufacturer's recommendations to ensure the installed cabling is consistent with the manufacturer's stated specifications. Testing plans shall be submitted for review and approval prior to the performance of any tests.

3.13 SPLICE ENCLOSURE TESTING REQUIREMENTS

- A. A bond clamp shall remain firmly attached to the cable armor sheath while under a tensile load of 9-kg (20 lbf). Following the removal of the load, there shall be no evidence of clamp loosening or damage to the cable sheath, armor, or clamp that would reduce its current carrying capacity as required by the AC fault test.
- B. The electrically conductive path used for continuity and grounding of the splice closure metallic components shall be capable of withstanding an AC current of 1000 Amperes for 20 seconds.
- C. The cable clamping and sealing hardware used to terminate optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at $1550 \text{ nm} \pm 20 \text{ nm}$.
- D. An axial load of 100 lbf, individually applied to each cable, shall not cause mechanical damage to the cable or clamping hardware. The load to the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at $1550 \pm 20 \text{ nm}$.
- E. Subjecting the closure/cable interface to 90° flexing for 8 cycles at ambient temperatures of $-18^\circ\text{C} \pm 2^\circ\text{C}$ ($0^\circ\text{F} \pm 3.6^\circ\text{F}$) and $40^\circ\text{C} \pm 2^\circ\text{C}$ ($104^\circ\text{F} \pm 3.6^\circ\text{F}$) shall not cause any mechanical damage to the cable or clamping hardware. In addition, flexing of the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at $1550 \pm 20 \text{ nm}$.
- F. Subjecting the closure/cable interface to 10 cycles of torsional loading at ambient temperatures of $-18^\circ\text{C} \pm 2^\circ\text{C}$ ($0^\circ\text{F} \pm 3.6^\circ\text{F}$) and $40^\circ\text{C} \pm 2^\circ\text{C}$ ($104^\circ\text{F} \pm 3.6^\circ\text{F}$) shall not cause any mechanical damage to the cable or clamping hardware. In addition, torsional loading of the optical fiber cable shall not exceed allowable attenuation changes.

- G. The closure shall not exhibit any mechanical damage after being subjected to a vertical drop from a height of 0.75 m (30 inches) at temperatures of $-18^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($0^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) and $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($104^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$).
- H. The diameter of the optical fiber splice closure shall not permanently deform more than 10%, nor temporarily deform more than 20%, when it is compressed by a uniformly distributed load of 300 lbf. Additionally, the compressive load shall cause no mechanical damage to the closure or its contents.
- I. The closure shall not exhibit any mechanical damage after being subjected to mechanical impact of 100 lbf (136 Nm) at temperatures of $-18^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($0^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) and $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($104^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$).
- J. The closure central member clamp shall prevent movement (e.g., bowing, pistoning, or breaking) of the cable central member (CM) when the CM exerts a force of 100 lbf on the clamp.
- K. Sealing components (gaskets, grommets, O-rings) used in a closure, shall not permit the entry of water into the closure after thermal aging at $90^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ($194^{\circ}\text{F} \pm 1.8^{\circ}\text{F}$) for 720 hours (30 days).
- L. The closure shall be capable of safe and proper assembly at temperatures of $0^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($32^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) and $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($104^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) using materials and procedures specified by the manufacturer.
- M. The closure shall not exhibit any mechanical damage or corrosion following 30 days of severe temperature and humidity cycling from $65^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($150^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) and 95% relative humidity to $-40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($-40^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) and uncontrolled humidity. Additionally, at the midpoint of the temperature cycle, re-entry and re-assembly of the closure shall be done. If the closure has a hinged cover, it shall be flexed 25 times.
- N. The closure shall show no evidence of water intrusion into the compartment containing fiber splices after it is immersed in water and subjected to 10 freeze/thaw cycles.
- O. The splice closure shall show no evidence of water penetration following exposure to a 20-foot waterhead for a period of 7 days.
- P. A closure shall show no evidence of corrosion following exposure to acidified saltwater for a period of 90 days.
- Q. The closure shall show no change in sealing ability after submersion in a specified chemical test fluid for 7 days. The mechanical integrity of the closure shall be confirmed by performing the compression and impact tests. The closure seal shall also be checked by performing the water immersion test. Additionally, samples of external, nonmetallic closure materials shall neither experience a change in weight greater than 10%, nor experience a reduction in tensile strength or elongation properties greater than 20%, after immersion in the chemical test fluid.
- R. Samples of external, nonmetallic closure materials shall not have a reduction in tensile strength or elongation properties greater than 20% of their original value, after being exposed to a UV-B type ultraviolet light source with a peak emission at 313 nm for 2,160 hours (90 days).
- S. Samples of polymeric closure materials shall not support fungus growth when tested per ASTM G 21. A rating of 0 is required.

3.14 COMPLETION

A. Results Expected

1. All equipment and materials shall be in place and all systems shall be demonstrated to be operationally complete.
2. All testing, start-up and cleaning work shall be complete.
3. All documented testing results are submitted and approved by the Architect.
4. All O & M Manuals and Record Documents are reviewed and accepted.
5. Substantial Completion inspection is performed and granted. The Substantial Completion inspection punch list is completed by the Contractor.
6. All facility training shall be complete and digital copies of the training sessions are reviewed.
7. All "minimum" twenty (20) year structured cable plant certifications and warranties are received.
8. Transmittal letter listing delivery of complete spare parts inventory.

3.15 MAINTENANCE MATERIALS

- #### A.
- Provide spare materials as indicated in Contract Documents and as required for proper maintenance of systems.

3.16 WARRANTY, WARRANTY SERVICE AND MAINTENANCE

A. Warranty

1. The Information Transport System shall have a factory warranty for twenty (20) years beginning on the date of Owner/User acceptance.
2. The Division 27 Components not covered under the Structured Cabling System "minimum" twenty (20) year warranty shall be fully guaranteed by the Contractor for a period of two (2) years beginning on the date of Owner/User acceptance.
3. The guarantee shall include the entire Division 27 Information Transport System scope of work including all equipment, devices, materials, cable/wire, and installation.
4. Work shall be guaranteed to be free from defects. Any defective materials or workmanship, as well as damage to the Work of all other Trades resulting from same, shall be replaced or repaired as directed by the Owner/User for a period of two (2) years from the date of Owner/User final acceptance. The Contractor shall provide written warranties for all systems and all buildings to the Owner/User.
5. The guarantee shall exclude acts of God, vandalism, physical abuse, or operator misuse.
6. Acceptance by a manufacturer of an order for equipment for this contract signifies acceptance of this warranty. During the warranty period there shall be no charge to the Owner/User for equipment, material, etc. for guaranteed work.
7. During the warranty period, there shall be no charges to the Owner/User for service calls (mileage, labor, travel, expenses, etc.) for guaranteed work.

B. Warranty Service

1. Warranty service shall be provided as part of this Contract by the Contractor during the warranty period.

END OF SECTION 270500

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. EMT: Electrical metallic tubing.
- B. TBB: Telecommunications Bonding Backbone
- C. SBB: Secondary Bonding Busbar
- D. PBB: Primary Bonding Busbar

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
- C. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.
- D. Telecommunications Grounding Riser Diagram: Provide a detailed riser diagram showing the interconnectivity of all grounding busbars (PBB and SBB), along with telecommunications bonding backbone (TBB) and calculations for determining the size of the TBB segments. This shall be reviewed and approved by the architect prior to installation.
- E. Installation, terminating, and splicing procedures.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.6 CLOSEOUT 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, PBB, SBBs, and routing of their bonding conductors.
- B. 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 SBB and its nearest grounding electrode.

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 Supervisor, 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 an RCDD to perform the on-site inspection.
- B. All electrical components, devices, and accessories related to bonding and grounding shall be listed and labeled as defined in NFPA 70 by a qualified testing agency marked for the intended location and application.
- C. Grounding: Comply with ANSI/TIA-607D and BICSI Telecommunications Distribution Methods Manual recommended practices.
- D. Labeling: Comply with ANSI/TIA-606D

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

- A. Comply with ANSI/TIA-607-D.

2.2 CONDUCTORS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Harger Lightning and Grounding
 - 2. Panduit Corp.
 - 3. Chatsworth
 - 4. Or Approved Equal by the Architect
- B. Comply with UL 486A-486B.

- C. Insulated Conductors: Stranded copper wire, with green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83. Equipment grounding conductors larger than No. 6 AWG shall be identified as recommended in the BICSI TDMM.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. Retain "Cable Tray Equipment Grounding Wire" Subparagraph below if an equipment grounding conductor is required. If the ground wire serves as the telecommunications bonding backbone, indicate wire size on Drawings.
 - 3. If cable tray contains electrical power conductors, then NFPA 70, Article 392 "Cable Trays" governs, and the minimum equipment grounding conductor size is No. 4 AWG.
 - 4. Cable Tray Equipment Grounding Wire: No. 6 AWG.
- D. Cable Tray Grounding Jumper:
 - 1. Not smaller than No. 6 AWG and not longer than 12 inches. 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. 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 B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 6 AWG, 14 strands of No. 17 AWG conductor, and 1/4 inch 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 wide and 1/16 inch thick.
 - 7. Bare copper conductors shall not be used in cable tray applications.

2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Harger Lightning and Grounding
 - 2. Panduit Corp.
 - 3. Chatsworth
 - 4. Or Approved Equal by the Architect
- 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 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. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Harger Lightning and Grounding
 - 2. Panduit Corp.
 - 3. Chatsworth
 - 4. Or Approved Equal by the Architect
- B. PBB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as required to allow for the quantity of connections indicated on Drawings plus 25% spare capacity. The busbar shall be NRTL listed for use as PBB and shall comply with J-STD-607-A.
 - 1. Hole patterns on the Busbars shall accommodate two-hole lugs per the recommendation of BICSI and ANSI/TIA-607-D-2019 standards.
 - 2. Mounting Hardware: wall-mount stand-off brackets, assembly screws and insulators that provide a 2 ½ -inch (63.5-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
- C. SBB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as required to allow for the quantity of connections indicated on the Drawings plus 25% spare capacity. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.
 - 1. Hole patterns on the Busbars shall accommodate two-hole lugs per the recommendation of BICSI and ANSI/TIA-607-D-2019.
 - 2. Mounting Hardware: wall-mount stand-off brackets, assembly screws and insulators that provide a 2 ½ -inch (63.5-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
- 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 J-STD-607-A. 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 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.

- a. Minimum of 16 grounding connections
- 3. Rack-Mounted Vertical Busbar: 72 or 36 inches long, with stainless-steel or copper-plated hardware for attachment to the rack.
- a. Minimum of 36 grounding connections

2.5 GROUND RODS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Harger Lightning and Grounding
 - 2. Erico
 - 3. Alltec
- B. Ground Rods: Copper-clad steel, 5/8 diameter by 96 inches long.
- C. Ground Rod Connections: Exothermic weld process. Caldweld Series "GRC".

2.6 LABELING

- A. Comply with the requirements within specification 27 05 53 "Identifications for Communications Systems"
- B. Comply with TIA/EIA-606-D and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

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 TBB connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the TBB only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. All installation of the Telecommunications Ground Systems shall be performed by a BICSI certified Installer. This includes but is not limited to:
 - 1. All busbars
 - 2. All bonding conductors

3. Bonding to all non-active (non-current carrying) metal support structures, rack, runway, etc. within each Telecommunication Room or Space. Coordinate this bonding with the supplier and installer of rack, runway, etc.
- B. Bonding shall include the communications cable entrance. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- C. Comply with NECA 1.
- D. Comply with ANSI/TIA-607-D.

3.3 SPECIFICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 1. The bonding conductors between the SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 2. The bonding conductors between the PBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 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.
- 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 intervals.
 4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT.
 - 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 SBB.

3.4 GROUNDING ELECTRODE SYSTEM

- A. The TBB between the PBB and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches 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 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 PBB with insulated bonding conductor.
- E. Interconnections: Interconnect all SBBs with the PBB with the telecommunications backbone conductor. If more than one PBB is installed, interconnect PBBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 14 AWG, 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 vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the SBB with a minimum of a No. 6 AWG bonding conductor.
- G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB 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 SBB to the ground bar of the panelboard.
- I. Shielded Cable: Bond the shield of shielded cable to the SBB in communications rooms and spaces. Comply with TIA/EIA-568-D.1 and TIA/EIA-568-D.2 when grounding screened, 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 SBB.
- L. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.
 - 1. Install the conductors in grid pattern on 4-foot centers, allowing bonding of one pedestal from each access floor tile.
 - 2. Bond the SBB 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 SBB at the perimeter of the room.
- M. Towers and Antennas:
 - 1. Ground Ring: Buried at least 30 inches below grade and at least 24 inches 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 below grade.
 - 3. Bond the ground ring and antenna grounds to the equipment room PBB or SBB, buried at least 30 inches below grade.
 - 4. Bond metallic fences within 6 feet of towers and antennas to the ground ring, buried at least 18 inches 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 SBB 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 SBB 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.

3.7 TELECOMMUNICATIONS RACEWAY AND SUPPORT SYSTEM GROUNDING

- A. Bond and ground raceway, cable rack or tray and conduit together and permanently ground to the equipment grounding busbar. Connection to conduit may be with grounding bushing or ground clamp.
- B. Connect ladder-type cable tray to grounding electrode system. Telecommunications cable tray that is located in the same room as the PBB shall be connected to the PBB.
- C. Bond and ground raceway at low voltage motor control centers or other low voltage control equipment, except conduit which is effectively grounded to sheet metal enclosure by bonding bushing or hubs need not be otherwise bonded.

- D. Where a grounding conductor is run in or on a cable tray, bond grounding conductors to each section of cable tray with a cable tray ground clamp.
- E. Where only grounding conductor is installed in a metal conduit, bond both ends of conduit to grounding conductors.
- F. Provide flexible "jumpers" around raceway expansion joints and across cable tray joints parted to allow for expansion and hinged cable tray connections. Provide copper bonding straps for steel conduit.

3.8 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Duct-Bank Grounding Conductor: Bury 12 inches 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 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 above to 6 inches 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.

3.9 IDENTIFICATION

- A. Comply with the requirements within specification 27 05 53 "Identifications for Communications Systems".
- B. Labels shall be preprinted or computer-printed type.
 - 1. Label PBB(s) with "fs-PBB," where "fs" is the telecommunications space identifier for the space containing the PBB.
 - 2. Label SBB(s) with "fs-SBB," where "fs" is the telecommunications space identifier for the space containing the SBB.
 - 3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: 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 PBB and a SBB 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 PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 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. Hooks.
 - 9. Boxes, enclosures, and cabinets.
 - 10. Polymer-concrete handholes and boxes for exterior underground cabling.
 - 11. 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. Boxes, enclosures, and cabinets.
 - 4. Underground handholes and boxes.
- B. Sustainable Design Submittals:
- 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" long per each.

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: 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 GENERAL

- A. All conduits shall be UL listed and labeled.
- B. Where conduit and other raceway sizes are not specifically shown on the plans, conduits shall be sized in accordance with the requirements of the local building code, BICSI and the NEC. Minimum conduit size shall be 1 inch.
- C. Raceways installed in stud walls or above suspended ceilings shall be Electrical Metallic Tubing. PVC conduit shall not be used.

2.2 METAL CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Allied Tube & Conduit.
 - 2. Anamet Electrical, Inc.
 - 3. Electri-Flex Company.
 - 4. FSR Inc.
 - 5. O-Z/Gedney.
 - 6. Republic Conduit.
 - 7. Robroy Industries.
 - 8. Southwire Company.

9. Thomas & Betts Corporation.
 10. Western Tube and Conduit Corporation.
 11. Wheatland Tube Company.
- B. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.
- C. RMC: Comply with ANSI C80.1 and UL 6.
- D. IMC: Comply with ANSI 80.6 and UL 1242.
- E. EMT: Comply with ANSI C80.3 and UL 797.
- F. High-strength zinc coated, 1-inch minimum size.
- G. EMT shall not be utilized for service entrance conductors.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel
 - b. Type: compression
 3. 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.
 - a. Manufacturers: OZ type AX, Appleton type XJB or approved equal.
 - b. Watertight, permitting two-way movement up to 4 inches, equipped with bonding jumpers around or through each fitting.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. 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.
- J. Thruwall Sealing Fittings: Type WSK by O-Z Gedney Company, or approved equal.
- K. Fire-Seal Fittings: Type CFSI by O-Z Gedney Company, or approved equal.
- L. Sealing Material for Sealing Fittings: Chico X Fiberdam, and Chico A sealing compound, or Chico A-P Interpak by Crouse-Hinds or Apelco sealing cement and fiber filler by Appleton, or approved equal.
- M. Insulated Bushings: Type B or SBT, as applicable by O-Z Gedney or series B1900, Series BU500 or series TC700 as applicable, by Steel City or approved equal.

- N. Pull-Wire: Provide 1200# nylon pull rope or mule tape in each empty conduit or innerduct for outdoor pathways. For indoor pathways, provide pull strings in each empty conduit or innerduct.
- O. Thread lubricant/sealant shall be Crouse-Hinds type STL or T&B Kopr-Shield except when required on joints for heat producing elements such as lighting fixtures, it shall be Crouse Hinds type HTL or approved equal.
- P. Wireways and wiring troughs shall be code gauge galvanized steel, sized as shown or required by the NEC. Covers shall be screwed. Where indicated as rain tight, wire ways shall be galvanized and shall comply with NEMA requirements.

2.3 INNERDUCT AND MICRODUCT

- A. Any fiber optic cable not in its own dedicated conduit pathway shall be either armored cable or installed within innerduct or microduct.
- B. Innerduct shall be available in ½ inch, ¾ inch, 1 inch, 1 ¼ inch, 1 ½ inch and 2 inch sizes.
- C. Any innerduct placed in space used as an air return or in any way connected with air handling plenums or building ventilation shall be low-smoke, fire retardant innerduct and must comply with the National Electrical Code Articles 725, 760, and 800. No cabling or innerduct shall be placed in plenums without prior written approval from Owner.
- D. Innerduct for Outdoor Use: Extruded, smooth wall, coilable tubing suitable for installation within an existing larger diameter conduit system. Innerduct shall be orange when only one innerduct is installed. Multiple innerducts in a single conduit shall be easily differentiable colors (blue, orange, green and brown). Outdoor innerduct can be either PVC or HDPE. Innerduct shall be installed in conduits as specified on the contract drawings.
- E. Innerduct for Interior Use: Extruded, smooth wall, coilable tubing suitable for installation within an existing larger diameter conduit system. Innerduct shall be orange when only one innerduct is installed. Multiple innerducts in a single conduit shall be easily differentiable colors (blue, orange, green and brown). Innerduct to be used in interior applications shall be manufactured from PVC and may have silicone impregnated interior surface. Innerduct shall be installed in conduits as specified on the contract drawings.
- F. FuturePath Microduct: FuturePath Microduct shall be installed in conduits as specified on the contract drawings.
- G. All innerduct and FuturePath Microduct ends will be capped with a correctly sized, application specific, duct plug/endcap. All spare innerducts shall have a pull string (length of pull determines string strength) installed for future use and be provided with an integral pull string tie-off. Couplings shall be non-metallic schedule 40. For any length of innerduct greater than 200 feet, a 1200 pound pull rope is required, shorter than 200-foot lengths can use a 200 pound pull string.
- H. All microduct runs shall be continuous from the end points identified on the contract drawings. Where microducts pass through pull boxes, handholes, manholes, or other access points they shall be coupled to provide a continuous pathway. All coupling shall conform to Duraline's recommended installation procedures.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Panduit
 - 2. Ortronics
 - 3. Wiremold
 - 4. Commscope
- B. 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.
- C. 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.
- D. 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.
- E. Solvents and Adhesives: As recommended by pathway manufacturer.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-B.
 - 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- E. Metal Floor Boxes:
 - 1. Material: Cast 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, rectangular.

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. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- I. Device Box Dimensions: 4-inches square by 2-1/8 inches deep or 4 inches by 2-1/8 inches by 2-1/8 inches deep.
- J. Gangable boxes are allowed.
- K. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4 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: Fiberglass.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- M. Cabinets:
 1. NEMA 250, Type 12, 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.

2.6 Firestopping and materials

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. STI
 2. Johns Manville
 3. Hilti
 4. Nelson
 5. Approved Equal
- B. Description
 1. Performance requirements: Provide fire stopping systems that are produced and installed to resist spread of fire according to requirement indicated, resist passage of smoke and other gases, and maintain fire resistance rating of assembly.

- a. F-Rated Systems: in accordance with ASTM E 814
 - b. T-Rated Systems: in accordance with ASTM E 814
2. Fire stopping flame spread performance requirements: Provide products with flame-spread ratings of less than 25 and smoke development ratings of less than 50 as determined in accordance with ASTM E 84.
3. Fire Stopping UL performance requirements: Provide products with UL ratings specified for assembly indicated as determined in accordance with UL listings.

PART 3 - EXECUTION

3.1 GENERAL

- A. Raceways shall be mechanically and electrically connected to all boxes and fitting and shall be properly grounded.
- B. All pathways shall be installed in such a fashion that the installation meets or exceeds all local seismic requirements.
- C. The routing and location of all conduits and other raceways shall be coordinated with other trades and with the building construction to avoid conflicts.
- D. Where raceways pass through walls, partitions and floors, seal penetrations to provide a neat installation which will maintain the integrity of the waterproofing or fireproofing, as applicable of the structure. Coordinate installation requirements with roofing manufacturer where conduits pass through the roof.
- E. All raceways entering a building from underground shall be sealed to prevent water, moisture, gas, or any other foreign matter from entering the building. Service conduits shall be sealed in accordance with NEC 230-8.
- F. All pathways shall be tested, post installation, to verify the pathway integrity and confirm that the pathway is suitable for the installation of communications cabling.

3.2 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: Type EPC-40-PVC, direct buried, concrete encased.
 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT or innerduct.
 5. Damp or Wet Locations: GRC.
 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.
 7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway Riser-type, communications-cable pathway EMT.
 8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway Plenum-type, communications-cable pathway EMT.
 9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Pathway Size: 1-inch trade size for copper and aluminum cables, and 1 inch 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 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.

3.3 CONDUIT INSTALLATION

- A. EMT - Provide insulated throat, threadless, compression type, malleable steel fittings. All EMT fittings shall be fabricated from steel. Die-cast fittings or fittings made from pot metal shall not be allowed. Install OZ type B bushings on conduits 1" and larger. Where conduits terminate in thread less opening, locknuts shall be provided both inside and outside of the box or enclosure and the conduit end shall be fitted with an insulating bushing. Where bonding is required, the end of the conduit shall be equipped with an insulated metallic grounding and bonding bushing.
- B. All metallic couplings, connectors and fittings shall be malleable iron or steel and finished with zinc plating or by galvanizing.
- C. All conduits shall be plugged after installation to prevent the entrance of construction dirt and debris. Conduits shall be cleaned before wires are pulled.
- D. Expansion fittings shall be utilized in all cases where conduits pass through building expansion joints. Fittings shall be of an approved weatherproof telescopic type permitting a movement of up to four inches and shall be provided with approved bonding jumpers around or through the fitting.

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 GRC and EMT conduit 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) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) 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 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.
- E. All conduits shall be properly supported using galvanized malleable iron conduit clamps for individual runs. Multiple runs shall be supported on channel adequately secured to walls or hung from structure above with conduits fastened to channel with clamps designed for the purpose. All pathways shall be installed to meet Local seismic requirements.
- F. Connection of Conduit to Sheet Metal Boxes and Enclosures:
1. Connection to NEMA 1 type boxes and enclosures: EMT- Install compression box connectors with insulated throats.
 2. Connection to NEMA 3R, 4, 4X, and 12 type boxes: Install insulated bushings and sealing locknuts or hubs.
 3. When conduits enter floor mounted enclosures from below and there is no sheet metal to which to attach; install grounding bushings on the conduit. Bond bushings to ground bus using a conductor the same size as required for an equipment grounding conductor sized for the given circuit.
 4. Install sealing bushing within all conduits which have entered a building from outside, whether from above or below grade.
- G. Verify all pathways are installed in accordance with Local Seismic requirements
- H. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- I. Complete pathway installation before starting conductor installation.
- J. Comply with requirements in Section 260530 "Hangers and Supports for Electrical Systems" for hangers and supports.

3.4 JUNCTION BOXES AND PULL BOXES

- A. All pull boxes shall be constructed of 14 or 12 gauge galvanized steel with an ANSI 61 grey polyester powder finish inside and out unless otherwise specified.
- B. All pull boxes supporting trade 4 (4-inch) sized conduits shall have continuous-hinge covers with a flush or handle latch to permit opening of the cover.
- C. All pull boxes shall provide the appropriate provisioning for grounding.
- D. All pull boxes shall be NEMA Type 1 and sized according to the table listed on contract documents.
- E. Verify all pull boxes are installed in accordance with Local Seismic requirements.

3.5 COMMUNICATIONS CONDUIT INSTALLATION

- A. No section of conduit shall be longer than 30m (100 ft) or contain more than two 90 degrees bends between pull points or pull boxes.
- B. The inside radius of a bend in a 2 inch or smaller conduit shall be at least 6 times the internal diameter. For all conduit larger than 2 inches the inside radius of a bend in the conduit shall be at least 10 times the internal diameter of the conduit.
- C. A measured pull cord shall be placed in installed conduit.
- D. All communications conduits shall be labeled in accordance to specification 27 05 54 "Identifications for Communications Systems"
- E. Conduit shall be reamed to eliminate sharp edges and terminated with an insulated bushing.
- F. Conduit protruding through the floor shall be terminated 4 inches above the finished slab.
- G. Pull or splice boxes shall be placed in an exposed manner and location, and readily accessible.
- H. A color-coded pull or splice box shall be placed in a conduit run where the length is over 30 m (100 ft), there are more than two 90 degree bends, or the total offset of the run exceeds 180 degrees.
- I. All conduit and cabinet entrances shall be sealed with an approved, re-enter able sealant material to prevent ingress of water, dust or other foreign materials.
- J. Verify all communications conduits are installed in accordance with Local Seismic requirements.

3.6 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."

3.7 FIRESTOPPING

- A. Compliance: Comply with manufacturer's product data, including product technical bulletins, product catalog installation instruction, and product carton instruction for installation.

- B. Site Verification of Conditions: Verify substrate conditions are acceptable for product installation in accordance with manufacturer's installation.
- C. Install firestopping at penetrations of fire-rated floor and wall assemblies. Install fire stopping to comply with performance requirements listed herein and Section 078413 "Penetration Firestopping".
- D. Install fire stopping to comply with listed fire rated assemblies in accordance with ASTM and UL requirements.
- E. Installer shall be trained and approved by the manufacturer. Protection: Protect installed products from damage during construction operations until final completion.
- F. Inspection: Code official or building inspectors to review proper installation using manufacturer's guidelines.

3.8 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

SECTION 270528.29 – 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 270528 – Pathways for Communications Systems

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: Signed and sealed by an RCDD. For fabrication and installation details for communications hangers and support systems including but not limited to the following:
 - 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.

B. Seismic Qualification 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.
 - 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. Rated and signed off by a licensed engineer for the seismic zone that the component(s) are located.
- C. Surface-Burning Characteristics: Comply with ASTM E 84; 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 D 635.

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. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 2. Material for Channel, Fittings, and Accessories: Galvanized steel.
 - 3. Channel Width: 1-5/8 inches.
 - 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 8. Channel Dimensions: Selected for applicable load criteria.
- B. Aluminum Slotted Support Systems: Extruded aluminum channels and angles with minimum 13/32-inch- diameter holes at a maximum of 8 inches o.c. in at least one surface.
 - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 2. Channel Material: 6063-T6 aluminum alloy.
 - 3. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 - 4. Channel Width: 1-5/8 inches.
 - 5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 8. 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 diameter holes at a maximum of 8 inches o.c., in at least one surface.
 - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 2. Retain first option below to allow Contractor to select size of slotted support system.
 - 3. Channel Width: 1-5/8 inches.
 - 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 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 A 36/A 36M 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.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 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 A 325.
 - 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/BICSI 568.
 3. TIA-569-D.
 4. NECA 101
 5. NECA 102.
 6. NECA 105.
 7. NECA 111.
- a. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
 - b. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
 - c. 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 in diameter.
 - d. 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.
8. Secure raceways and cables to these supports with two-bolt conduit clamps.
- B. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch 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.
- 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 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 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.
- B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" 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 A 780.

END OF SECTION 270528.29

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. Ladder cable tray.
 - 2. Wire-mesh cable tray.
 - 3. Cable tray accessories.
 - 4. Warning signs.
- B. Related Requirements:
 - 1. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

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 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.
 - 1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

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. Manufacturers:

1. Chatsworth Products Inc (CPI), UL Classified Cable Runway
2. Legrand Cablofil
3. Thomas and Betts
4. Monosystems
5. B-line
6. Chalfant

B. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: As indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches.
4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 9 inches o.c.
6. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch 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 concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: 24 inches
11. Splicing Assemblies: Bolted type using serrated flange locknuts.
12. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
13. Hardware and Fasteners: Metal suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inches (0.012 mm) thick.
14. Provide cable runaway radius drop at cable transitions from tray to racks. Width of waterfall/radius drop shall match the entire width of the ladder cable tray.
 - a. Provide grounding clamps and #6 AWG ground wire.
15. Finish: Powder-coat enamel paint.
 - a. Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - b. Hardware: Chromium-zinc plated, ASTM F 1136.
 - c. Finish Color: Black

2.4 WIRE-BASKET CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Chatsworth Products Inc. (CPI)
 2. WBTray (Shaped Tray)
 3. Or Approved Equal by the Owner
- B. Description:
1. Configuration: Wires are formed into a standard 2-by-4-inch (50-by-100-mm) wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.
 2. Materials: High-strength-steel longitudinal wires with no bends.
 3. Safety Provisions: Wire ends along wire-basket sides (flanges) rounded during manufacturing to maintain integrity of cables and installer safety.
 4. Sizes:
 - a. Straight sections shall be furnished in standard 118-inch (3000-mm) lengths.
 - b. Cable tray size as shown on the floor plans.
 5. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings.
 6. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
 7. Hardware and Fasteners: Metal suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inches (0.012 mm) thick.
 8. Provide all fittings and accessories required to protect, support and install a ladder rack support system.
 9. Provide grounding clamps and #6 AWG ground wire.
 10. Finish: Electrogalvanized before fabrication.
 - a. Standard: Comply with ASTM B 633.
 - b. Hardware: Galvanized, ASTM B 633.

2.5 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.

2.6 WARNING SIGNS

- A. Lettering: 1-1/2-inch high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."
- B. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to 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. Comply with requirements in Section 270528.29 "Hangers and Supports for Communications Systems." Comply with seismic-restraint details according to Section 270548.16 "Seismic Controls for Electrical 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 VE 2. Do not install more than one cable tray splice between supports.
- M. Support wire-basket cable trays with trapeze hangers.
- N. Support trapeze hangers for wire-basket trays with 3/8-inch 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 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 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.
- 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.
- E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches 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. LEED Submittals:
 - 1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, 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 D 1785, 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 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 pathway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or Architect approved equivalent:
 - a. Hilti Speed Sleeves
 - b. Advance Products & Systems, Inc.
 - c. CALPICO, Inc.
 - d. Metraflex Company (The)
 - e. Pipeline Seal and Insulator, Inc.
 - f. 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 or Architect approved equivalent:
 - a. HOLDRITE
 - b. Hilti

2.4 GROUT

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

- B. Standard: ASTM C 1107/C 1107M, 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.

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.
- 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 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 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 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 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.

3.4 OWNER'S QUALITY ASSURANCE

- A. Architect's independent commissioning and witnessing agency will provide the following witnessing and/or review services:
 1. Review all sleeve seal system installations.

END OF SECTION 270544

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 GENERAL

- A. All identification materials and labels shall be machine generated, hand-written labels will not be accepted.
- B. All labels must be legible, printed with all capital letters, and may not be smaller than 10pt Arial font or 0.13" in height. At least 4 point spacing between lines must be maintained in all labels that require two or more lines.

2.2 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and TIA 606-D.
- 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, ambient; 180 deg F, material surfaces.

2.3 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 - 1. Black letters on a white field.

2.4 CABINET AND RACK IDENTIFICATION MATERIALS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick.
 - 1. Engraved with white letters on black face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Font size shall be no smaller than 1 inch.

2.5 TELECOMMUNICATIONS/EQUIPMENT ENCLOSURE IDENTIFICATION MATERIALS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick.
 - 1. Engraved with white letters on black face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Font size shall be no smaller than 1 inch.

2.6 CONDUIT AND FIBER CABLE IDENTIFICATION MATERIALS

- A. Pre-labeled steel, anodized steel, or aluminum tags attached to the conduit or fiber cable utilizing the Panduit Pan-Steel System. All identification materials must be weather and chemical resistant.

2.7 HORIZONTAL AND PATCH CABLE IDENTIFICATION MATERIALS

- A. Self-adhesive, self-laminating polyester white labels with black text that shall be sized appropriately to wrap around and securely adhere to the cable.

2.8 WORK AREA OUTLET FACEPLATES

- A. Self-adhesive, self-laminating polyester white labels with black text that is font size 20pt.

2.9 COPPER AND FIBER PATCH PANEL IDENTIFICATION MATERIALS

- A. Self-adhesive, self-laminating clear polyester labels that shall be sized appropriately to fit the horizontal copper or fiber patch panel.
- B. Arial, or Owner approved equivalent font shall be used with a font size of 14pt.

2.10 ACTIVE TELECOMMUNICATIONS EQUIPMENT IDENTIFICATION MATERIALS

- A. Self-adhesive, self-laminating polyester labels that shall be sized appropriately to fit the active telecommunications device.
- B. Clear adhesive labels may be used; however the lettering must contrast with the mounting surface for legibility (e.g. no black text on a dark surface, or white text on a light surface).

2.11 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:
 - a. Panduit
 - b. Hellerman Tyton
 - c. Brady Corporation
- 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. Manufacturers:
 - a. Panduit
 - b. Hellerman Tyton
 - c. Brady Corporation
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil thick, polyester flexible labels with acrylic pressure-sensitive adhesive.
 - 1. Manufacturers:
 - a. Panduit
 - b. Brother International
 - c. Brady Corporation
 - 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: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers:
 - a. Panduit
 - b. Brother International
 - c. Brady Corporation
 - d. Hellerman Tyton
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.

2.12 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 of raceway or cable they identify, that stay in place by gripping action.
 1. Manufacturers:
 - a. Panduit
 - b. Hellerman Tyton
 - c. Brady Corporation

2.13 UNDERGROUND-LINE WARNING TAPE

- A. Manufacturers:
 1. Brady Corporation
 2. Ideal Industries
 3. LEM 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".
- D. Tag: Type I
 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.
 3. Thickness: 4 mils.
 4. Weight: 18.5 lb/1000 sq. ft.

5. Tensile according to ASTM D 882: 30 lbf and 2500 psi

E. Tag: Type II:

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.
3. Thickness: 12 mils.
4. Weight: 36.1 lb/1000 sq. ft.
5. Tensile according to ASTM D 882: 400 lbf and 11,500 psi.

F. Tag: Type ID:

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.
3. Overall Thickness: 5 mils.
4. Foil Core Thickness: 0.35 mil.
5. Weight: 28 lb/1000 sq. ft.
6. Tensile according to ASTM D 882: 70 lbf and 4600 psi

G. Tag: Type IID

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.
3. Overall Thickness: 8 mils.
4. Foil Core Thickness: 0.35 mil.
5. Weight: 34 lb/1000 sq. ft.
6. Tensile according to ASTM D 882: 300 lbf and 12,500 psi.

2.14 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers:
 - a. Carlton industries
 - b. Champion America
2. Preprinted aluminum signs, high-intensity reflective, 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:

- a. Brady Corporation
 - b. Champion America
- 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:
- D. Manufacturers:
Brady Corporation
- E. Carlton Industries
 - 1. Engraved legend.
 - 2. 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.

2.15 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 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 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 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 high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches 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 below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope 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.

3.3 IDENTIFICATION SCHEDULE

- A. General

1. Digital records of all labels produced and applied shall be digitally submitted to the Architect as part of the closeout documents.
- B. 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.
- C. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- D. 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.
- E. Faceplates: Labeled with a unique alphanumeric identifier as per TIA-606-D
- F. 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.
- G. Backbone Cables: Label each cable with a vinyl-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.
- H. Horizontal Cables: Label each cable with a vinyl-wraparound label indicating the following, in the order listed:
 1. Room number.
 2. Colon.
 3. Faceplate number.
- I. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
- J. Instructional Signs: Self-adhesive labels.
- K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.
 1. Apply to exterior of door, cover, or other access.
- L. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.
2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign. Stenciled legend 4 inches 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.

END OF SECTION 270553

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 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
 - 3. Section 271500 "Communications Copper Horizontal Cabling" for copper 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. SBB: Secondary Bonding bus bar.
- F. PBB: Primary Bonding bus bar.
- G. UPS: Uninterruptible Power Supply

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 an RCDD.
 - 2. Installation Supervision: Installation shall be under direct supervision of the Field Supervisor, 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 to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment frames shall adhere to local seismic requirements.
 - 1. Communication rooms where indicated in the drawings that require protection from seismic events shall be equipped with seismic isolation platforms. These platforms shall be 'ball and cone' design meeting the UBC/IBC Seismic Zone 4 requirements.

2.2 BACKBOARDS

- A. Backboards: Within telecommunications spaces (MDF/IDF) a minimum of AC grade plywood shall be installed on all walls. Plywood sheets shall be minimum $\frac{3}{4}$ " in thickness and measure 4'x8'.

- B. Backboard Paint: Light-colored fire-retardant paint shall be utilized on all sides with a minimum of 2 coats of paint. This includes any cutout areas.

2.3 EQUIPMENT CABINETS FOR MAIN DISTRIBUTION FRAME (MDF)

- A. Manufacturers
 - 1. APC
 - 2. Or approved equal by the Owner
- B. General Requirements
 - 1. Rack Units: 42U
 - 2. Model/Model Number: Netshelter SX 42U Server Rack Enclosure Gen2

2.4 EQUIPMENT RACKS FOR MAIN DISTRIBUTION FRAME (MDF) AND INTERMEDIATE DISTRIBUTION FRAME (IDF)

- A. Manufacturers
 - 1. Chatsworth (P/N: 55053-715)
- B. General Frame Requirements
 - 1. Racks shall be 2-post and 52RU in height.
 - 2. Color: Black

2.5 TELECOMMUNICATION ENCLOSURES

- A. Manufacturers
 - 1. Hoffman
 - 2. Approved equal
- B. Telecommunication Enclosures (TE) shall have a minimum of 18 Rack Unit capacity and must not exceed a height of 40". The TE's must meet the following at minimum:
 - 1. Weatherproof, NEMA 4X rated
 - 2. Constructed of stainless steel with a bare finish
 - 3. Lockable with key access
 - 4. Contain a Card Access Security System (CASS) tamper switch where indicated on the drawings. CASS tamper switch must be compatible with the division 28 specifications and coordinated with the security contractor.
- C. Accessories
 - 1. HF10 Side-Mount Filter Fan, 115v (Model# HF1016513)

2.6 POWER

- A. Manufacturers:
 - 1. APC
- B. Power Distribution Units: 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. Contractor to supply PDUs based upon contract documents as noted on plans.
3. PDUs shall plug into either L5-20R or L5-30R receptacles, coordinate with the contract documents for electrical service above cabinets/racks.
4. Height: 0 RU Vertically mounted.
5. Housing: Metal.
6. Minimum of Six 5-20R receptacles.
7. LED indicator lights for power and protection status.
8. LED indicator lights for reverse polarity and open outlet ground.
9. Close-coupled, direct plug-in.
10. Rocker-type on-off switch, illuminated when in on position.
11. Each pair of PDUs shall connect to different electrical feeds (A/B power) to provide resiliency from any building supplied power issues. Coordinate electrical outlet location with Electrical Contractor to ensure power cord will reach outlet. Provide strain relief on electrical cord at outlet.
12. Surge Protection: UL 1449, Type 3.
 - a. Maximum Surge Current, Line to Neutral: 27 kA.
 - 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 for neutral to ground.

C. Uninterruptible Power Supply:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contractor to supply the following UPS based upon contract documents as noted on plans.
 - a. UPS 3000VA, 2U, L5-30 Input
 - b. UPS 1500VA, 2U, L5-15 Input
 - c. UPS Extended Run Battery Pack

2.7 PATCH CABLE MANAGMENT

- A. Horizontal wire managers: Provide horizontal 1RU and 2RU per the contract documents.- Cable management shall have covers that can be easily removed to access cables.
- B. Vertical wire managers: Provide 10-inch vertical wire management between racks and at the ends of a row of racks.
- C. Manufacturers:
 1. Chatsworth

2.8 GROUNDING

- A. Comply with requirements in section 270527 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

2.9 LABELING

- A. Refer to section 270554 "Labeling for Communications Systems".

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Refer to the contract documents for exact Entrance Facility (EF) / Demarc location.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for materials and installation requirements for underground pathways.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation and layout of equipment in communications equipment spaces.
- C. Plastic cable ties shall not be used on any communications cables at any location within this project. All communications cables shall be bundled using Velcro wraps of the appropriate length. Velcro ties shall be installed in such a manner the cables may be easily removed or added to the cable bundle. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. 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 Architect 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.
- E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
- F. Backboards:
 - 1. Install from 12 inches to 9 feet 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.
 - 4. All anchors shall be flush with the surface of the plywood after mounting.

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".

3.5 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with ANSI-J-STD-607-D.
- 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. Comply with requirements in Section 270554 "Identification for Communications 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/EIA-606-D for Class 2 level of administration including optional identification requirements of this standard.
- D. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

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. This section includes the requirements for the installation of communications cabling, associated supporting components, and equipment which includes the following:
 - 1. Backbone copper cabling.
 - 2. Backbone and horizontal optical fiber cabling.
 - 3. Cable connecting hardware, patch panels, and cross-connects.
 - 4. 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. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.
- E. LAN: Local area network.
- F. NRTL: Nationally Recognized Testing Laboratories
- G. OSP: Outside Plant
- H. RCDD: Registered Communications Distribution Designer.

1.4 BACKBONE OPTICAL FIBER CABLING DESCRIPTION

- A. A fiber optic cabling distribution system shall be provided as part of an overall campus-wide structured cabling system. The system shall be installed as depicted on the contract drawings.

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 a format approved by the Architect.

2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 3. Communication system block diagram
 4. Details of all connections to power sources, including grounding.
 5. Details of all surge protection device installations.
 6. Details of underground cable installation and cable entrance to buildings.
 7. Details of all cable routing in buildings.
 8. Cabling administration drawings and printouts.
 9. Wiring diagrams to show typical wiring schematics including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 10. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 11. 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 side 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. Optical fiber cable testing plan.

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 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 the filed supervisor, 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.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Test fiber optical cables upon receipt at Project site.

1. Testing of fiber optic cables when received on-site is recommended for the Contractor's convenience. Contractor shall be responsible for ensuring that 100% of all fiber optic strands installed meet the specification requirements.

1.9 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.
- B. Underground duct banks and Manholes: Outdoor duct banks and manholes may contain liquid. Depths vary seasonally and with recent precipitation. Liquid depths may vary from approximately 2 to 10 feet. Contractor shall be required to dewater duct banks and manholes.
- C. Contractor shall be required to comply with all applicable safety regulations.
- D. The Contractor shall be responsible for determining actual existing site conditions.

1.10 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Architect's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND EQUIPMENT SPECIFICATIONS

2.2 OPTICAL FIBER CABLE

- A. Manufacturers: Subject to compliance with the requirements, provide products by one of the following or Architect approved equivalent:
 1. Commscope
 2. Corning
- B. General Fiber Specifications
 1. All fiber optic cable will meet or exceed the attenuation specification of the TIA-568-D.3 T for the relevant optical fiber type.
 2. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
 3. Each optical fiber shall consist of a doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.
 4. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m²).
 5. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
 6. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 °C on the original shipping reel.

7. All fibers in the cable must be usable and meet required specifications.

C. Single-mode (Dispersion Un-shifted)

1. The single-mode fiber utilized in the optical fiber cable shall meet TIA-492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652.C, "Characteristics of a single-mode optical fibre cable."

- a. Cladding Diameter: $125.0 \pm 0.7 \mu\text{m}$
- b. Core-to-Cladding Concentricity: $\leq 0.5 \mu\text{m}$
- c. Cladding Non-Circularity: $\leq 0.7 \%$

$$\left(1 - \frac{\text{Minimum Cladding Diameter}}{\text{Maximum Cladding Diameter}}\right) \times 100$$

Defined as:

- d. Mode Field Diameter: $9.2 \pm 0.4 \mu\text{m}$ at 1310 nm $10.4 \pm 0.5 \mu\text{m}$ at 1550 nm
- e. Coating Diameter: $245 \pm 5 \mu\text{m}$
- f. Colored Fiber Nominal Diameter: 253 - 259 μm .
- g. Cabled Fiber Attenuation:
- h. $\leq 0.4/0.4/0.3 \text{ dB/km}$ at 1310/1383/1550 nm (for Loose Tube cable)
- i. $\leq 1.0/1.0/0.75 \text{ dB/km}$ at 1310/1383/1550 nm (for Tight Buffered cable)
- j. Attenuation Uniformity: No point discontinuity greater than 0.05 dB at either 1310 nm or 1550 nm.
- k. Macrobend Attenuation: The attenuation due to 1 turn of fiber around a $32 \pm 2 \text{ mm}$ diameter mandrel shall not exceed 0.05 dB at 1550 nm.
- l. The attenuation due to 100 turns of fiber around a $50 \pm 2 \text{ mm}$ diameter mandrel shall not exceed 0.05 dB at 1310 nm nor 0.10 dB at 1550 nm.
- m. Cable Cutoff Wavelength (λ_{ccf}): $< 1260 \text{ nm}$.
- n. Zero Dispersion Wavelength (λ_0): $1302 \text{ nm} \leq \lambda_0 \leq 1322 \text{ nm}$
- o. Zero Dispersion Slope (S_0): $\leq 0.089 \text{ ps}/(\text{nm}^2 \cdot \text{km})$
- p. Dispersion: $\leq 3.5 \text{ ps}/(\text{nm} \cdot \text{km})$ from 1285 - 1330 nm
- q. $\leq 17.5 \text{ ps}/(\text{nm} \cdot \text{km})$ at 1550 nm.
- r. Fiber Curl: $> 4.0 \text{ m}$ radius of curvature
- s. Cabled Fiber Polarization Mode Dispersion (PMD): $\leq 0.2 \text{ ps}/\sqrt{\text{km}}$
- t. IEEE 802.3 Performance: New single mode fiber shall support 10 Gigabit Ethernet (10 GbE) to distances of up to 10,000 Meters @ 1310 nm and 40,000 meters @ 1550 nm.

D. Fiber Optic Cable Specification, Loose Tube Design for Outdoor Installation

1. General Considerations

- a. The cable shall meet all requirements stated in this specification. The cable shall be an accepted product of the United States Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900 and meet the requirements of ANSI/ICEA Standard for Fiber Optic Outside Plant Communications Cable, ANSI/ICEA S-87-640-2006.

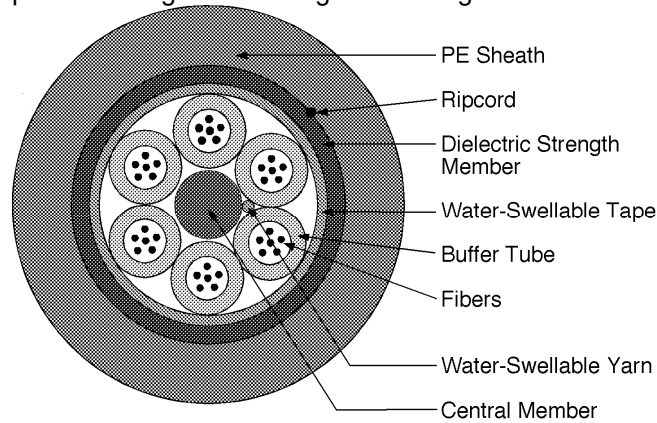
2. Fiber Characteristics

- a. See Multimode and single-mode fiber specifications above, fibers must be manufactured using the Outside Vapor Deposition (OVD) method.

E. Specifications for Outdoor Cable Construction

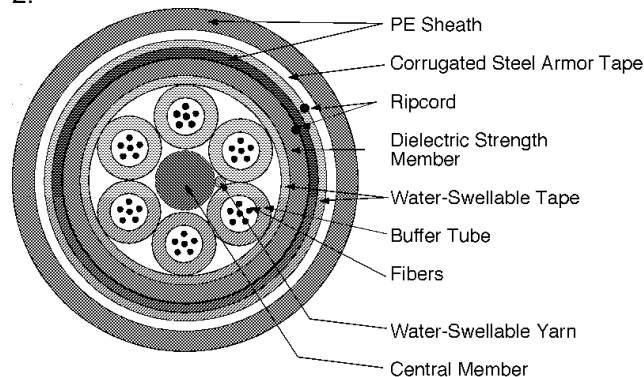
1. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.
2. Each buffer tube shall contain up to 12 fibers.
3. The fibers shall not adhere to the inside of the buffer tube.
4. Each fiber shall be distinguishable by means of color-coding in accordance with TIA-598-D, "Optical Fiber Cable Color Coding."
5. The fibers shall be colored with ultraviolet (UV) curable inks.
6. Buffer tubes containing fibers shall be color-coded with distinct and recognizable colors in accordance with TIA-598-D, "Optical Fiber Cable Color Coding."
7. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm.
8. For cables containing more than 12 buffer tubes, standard colors are used for tubes 1 through 12 and stripes are used to denote tubes 13 through 24. The color sequence applies to tubes containing fibers only, and shall begin with the first tube. If fillers are required, they shall be placed in the inner layer of the cable. The tube color sequence shall start from the inside layer and progress outward.
9. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
10. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements of 7 CFR 1755.900.
11. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes. In dual layer cables, any fillers shall be placed in the inner layer. Fillers shall be nominally 3.0 mm in outer diameter.
12. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod (optional steel central member). The purpose of the central member is to provide tensile strength and prevent buckling. The central member shall be over coated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/fillers.
13. Each buffer tube shall contain a water-swellaable yarn for water-blocking protection. The water-swellaable yarn shall be non-nutritive to fungus, electrically non-conductive, and homogeneous. It shall also be free from dirt or foreign matter. This yarn will preclude the need for other water-blocking material; the buffer-tube shall be gel-free.
14. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "S-Z", stranding process. Water swellaable yarn(s) shall be applied longitudinally along the central member during stranding.
15. Two polyester yarn binders shall be applied contrahelically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.
16. For single layer cables, a water swellaable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The water swellaable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.
17. For dual layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a two-layer core. A water swellaable tape shall be applied longitudinally over both the inner and outer layer. The water swellaable tape shall be non-

- nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.
18. Non-armored cables shall contain at least one ripcord under the sheath for easy sheath removal. Armored cables shall contain at least one ripcord under the inner sheath and at least one ripcord under the steel armor for easy sheath removal.
 19. Tensile strength shall be provided by the central member, and additional dielectric yarns as required.
 20. The dielectric yarns shall be helically stranded evenly around the cable core.
 21. Non-armored cables shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members (as required) and water swellable tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. See Figure 1.



22. Figure 1
23.

24. Armored cables shall have an inner sheath of MDPE. The minimum nominal jacket thickness of the inner sheath shall be 1.0 mm. The inner jacket shall be applied directly over the tensile strength members (as required) and water swellable tape. A water swellable tape shall be applied longitudinally around the outside of the inner jacket. The armor shall be a corrugated steel tape, plastic-coated on both sides for corrosion resistance, and shall be applied around the outside of the water blocking tape with an overlapping seam with the corrugations in register. The outer jacket shall be applied over the corrugated steel tape armor. The outer jacket shall be a MDPE with a minimum nominal jacket thickness of 1.4 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. See Figure 2.



25. Figure 2
26.

27. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8.

28. The jacket or sheath shall be free of holes, splits, and blisters.
29. The cable jacket shall contain no metal elements and shall be of a consistent thickness.
30. Cable jackets shall be marked with the manufacturer's name, month and year of manufacture, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code[□] (NESC®), fiber count, and fiber type. The actual length of the cable shall be within -0/+1% of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5 mm.
31. If the initial marking fails to meet the specified requirements (i.e., improper text statement, color, legibility, or print interval), the cable may be remarked using a contrasting alternate color. The numbering sequence will differ from the previous numbering sequence, and a tag will be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color will be yellow, with the secondary choice being blue.
32. The maximum pulling tension shall be 2700 N (608 lb/f) during installation (short term) and 890 N (200 lb/f) long term installed.
33. The shipping, storage, and operating temperature range of the cable shall be -40°C to +70°C. The installation temperature range of the cable shall be -30°C to +70°C.

F. General Cable Performance Specifications

1. When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation at extreme operational temperatures (-40°C and +70°C) shall not exceed 0.15 dB/km at 1550 nm for single-mode fiber and 0.3 dB/km at 1300 nm for multimode fiber.
2. When tested in accordance with FOTP-82, "Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable," a one-meter length of undamaged cable shall withstand a one-meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end.
3. When tested in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable, the cable shall exhibit no flow (drip or leak) of filling and/or flooding material at 70°C.
4. When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of the sample. The 220 N/cm (125 lbf/in) load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm (63 lbf/in). Alternatively, it is acceptable to remove the 220 N/cm (125 lbf/in) load entirely and apply the 110 N/cm (63 lbf/in) load within five minutes at a rate of 2.5 mm (0.1 in) per minute. The 110 N/cm (63 lbf/in) load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm (63 lbf/in) load. The change in attenuation shall not exceed 0.15 dB at 1550 nm for single-mode fibers and 0.3 dB at 1300 nm for multimode fiber.
5. When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The change in attenuation shall not exceed 0.15 dB at 1550 nm for single-mode fiber and 0.3 dB at 1300 nm for multimode fiber.
6. When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," except that the number of cycles shall be two at three locations along a one meter cable length and the impact energy shall be at least 4.4 Nm (in accordance with ICEA S-87-640)", the change in attenuation shall not exceed 0.15 dB at 1550 nm for single-mode fiber and 0.3 dB at 1300 nm for multimode fiber.

7. When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a rated tensile load of 2670N (601 lbf) and residual load of 30% of the rated installation load. The axial fiber strain shall be $\leq 60\%$ of the fiber proof level after completion of 60 minute conditioning and while the cable is under the rated installation load. The axial fiber strain shall be $\leq 20\%$ of the fiber proof level after completion of 10 minute conditioning and while the cable is under the residual load. The change in attenuation at residual load and after load removal shall not exceed 0.15 dB at 1550 nm for single mode fiber and 0.3 dB at 1300 nm for multimode fiber.
8. When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.15 dB at 1550 nm for single-mode fiber and 0.3 dB at 1300 nm for multimode fiber.
9. When tested in accordance with FOTP-181, "Lightning Damage Susceptibility Test for Optic Cables with Metallic Components," the cable shall withstand a simulated lightning strike with a peak value of the current pulse equal to 105 kA without loss of fiber continuity. A damped oscillatory test current shall be used with a maximum time-to-peak value of 15 μ s (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz. The time to half-value of the waveform envelope shall be from 40 - 70 μ s.
10. When tested in accordance with FOTP-37, "Low or High Temperature Bend Test for Fiber Optic Cable," the cable shall withstand four full turns around a mandrel of ≤ 20 times the cable diameter after conditioning for four hours at test temperatures of -30°C and $+60^{\circ}\text{C}$. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears, or other openings. The change in attenuation shall not exceed 0.3 dB at 1550 nm for single mode fiber and 0.5 dB at 1300 nm for multimode fiber

2.3 INSIDE PLANT FIBER OPTIC HARDWARE

- A. Manufacturers: Subject to compliance with the requirements, provide products by one of the following or Architect approved equivalent:
 1. Commscope
 2. Corning
- B. Description: Single Mode inside plant optical fiber, OS2 type, with fiber counts as indicated on drawings, with mechanical and transmission performance specifications that meet or exceed ANSI/TIA/EIA-568-D.3
 1. Comply with TIA/EIA-568-D.0
 2. Comply with ICEA S-83-596 for mechanical properties.
 3. Comply with TIA/EIA-568-D.3 for performance specifications.
 4. 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:
 - a. General Purpose, Nonconductive: Type OFN or OFNG [or OFNR, OFNP].
 - b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - c. Riser Rated, Nonconductive: Type OFNR [or OFNP], complying with UL 1666.
 - d. General Purpose, Conductive: Type OFC or OFCG [or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP].
 - e. Plenum Rated, Conductive: Type OFCP [or OFNP], complying with NFPA 262.

- C. Jacket:
 - 1. Jacket Color: Aqua for 50/125-micrometer cable.
 - 2. Jacket Color: Yellow for single-mode cable.
 - 3. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
 - 4. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
- D. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 - 1. Number of Connectors per Field: One for each fiber cable or cables assigned to field.
 - 2. Spares: The contractor shall provide an additional 10% of fiber patch cables above what is installed per the contract drawings in addition to (100) 1 meter, (100) 3 meter, and (100) 10 meter fiber patch cables which shall be stored on site as spares.
- E. Patch Cables: Factory-made, LC Duplex connector.
- F. Cable Connecting Hardware:
 - 1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-D.3.
 - 2. Quick-connect, simplex and duplex, Type LC connectors or current agreed standard at time of installation. Insertion loss not more than 0.7 dB.
 - 3. Reflectance loss: -20dB minimum
 - 4. Durability: < 0.2dB change, 500 re-matings, FOTP-21
 - 5. Optimally keyed, allowing reproducible mating conditions each time a connection is made between connector and coupler.
 - 6. Fitted with color-coded strain relief boots to ensure durable and robust connections.
 - 7. Fitted with a tight fitting, polymer cap over the connector to prevent ingress of dirt and dust until the connector is fitted to a coupler.
 - 8. All connectors to be straight-pull and side-pull resistant, preventing accidental optical disconnect; comply with FOTP-21.

2.4 FIBER OPTIC OUTSIDE PLANT SPLICE CLOSURES

- A. General Considerations
 - 1. The optical fiber splice closure shall meet all requirements stated in this specification.
 - 2. Splicing shall only be provided when noted on the contract drawings and approved, in writing, by the Owner.
- B. Splice Closure Features and Functions
 - 1. The splice closure housing shall be non-metallic. It shall be resistant to solvents, stress cracking, and creep. The housing materials shall also be compatible with chemicals and other materials to which they might be exposed in normal applications.
 - 2. The optical fiber closure shall be capable of accepting any optical fiber cable used in interoffice, outside plant, and building entrance facilities.
 - 3. The optical fiber closure shall be available in distinct sizes to accommodate a variety of cable entries as specified in the table below:

Table 2-1: Cable Capacity

Cable Capacity	Canister (Butt) Configuration		Branch (In-Line) Configuration	
	Express Entries/ Max. Cable Diameter (mm)	Drop Port Entries/ Max. Cable Diameter (mm)	Express Entries/ Max. Cable Diameter (mm)	Drop Port Entries/ Max. Cable Diameter (mm)
Large	2/32	6/25	4/32	12/25
Medium	2/25	4/18	4/25	8/18
Small	2/20	3/15	4/20	6/15

- a. As an option, the ability to double the cable capacity of an installed canister splice closure by use of a kit shall be available. Such a conversion shall not disturb existing cables or splices.
4. Encapsulation shall not be required to resist water penetration.
 5. The splice closure shall be re-enterable. The closure end cap shall be capable of accepting additional cables without removal of the sheath retention or strength member clamping hardware on previously installed cables or disturbing existing splices. The optical fiber splice closure shall provide a clamping mechanism to prevent pistoning of the central member or strength members and to prevent cable sheath slip or pullout.
 6. The splice closure shall have appropriate hardware and installation procedures to facilitate the bonding and grounding of metal components in the closure and the armored cable sheath. The cable bonding hardware shall be able to accommodate a copper conductor equal to or larger than a #6 AWG.
 7. Aerial splice closures shall have available the necessary hardware to attach and secure the closure to an aerial strand.
 8. The closure shall accommodate splice trays suitable for single fiber, single fiber heat shrink, mechanical, or ribbon heat shrink splices.
 9. The small splice closure shall accommodate up to 72 single fiber splices or 144-ribbon fiber splices using 12-fiber ribbons. The medium sized closure shall accommodate up to 288 single fiber splices or 432-ribbon fiber splices. The large closure shall accommodate up to 480 single fiber splices or 864-ribbon fiber splices.
 10. Spliced fibers shall not be subjected to a bend radius smaller than 30 mm (1.2 inches). Buffer tubes shall not be subjected to a bend radius smaller than 38 mm (1.5 inches).
 11. The installation of the splice closure shall not require specialized tools or equipment, other than those normally carried by installation crews.
- C. Splice Closure Performance Requirements
1. A bond clamp shall remain firmly attached to the cable armor sheath while under a tensile load of 9-kg (20 lbf). Following removal of the load, there shall be no evidence of clamp loosening or damage to the cable sheath, armor, or clamp that would reduce its current carrying capacity as required by the AC fault test.
 2. The electrically conductive path used for continuity and grounding of the splice closure metallic components shall be capable of withstanding an AC current of 1000 Amperes for 20 seconds.
 3. The cable clamping and sealing hardware used to terminate optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at $1550 \text{ nm} \pm 20 \text{ nm}$.
 4. An axial load of 100 lbf, individually applied to each cable, shall not cause mechanical damage to the cable or clamping hardware. The load to the optical fiber cable shall not cause an attenuation change greater than ± 0.05 dB per fiber, when tested with a source operating at $1550 \pm 20 \text{ nm}$.

5. Subjecting the closure/cable interface to 90° flexing for 8 cycles at ambient temperatures of $-18\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($0\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($104\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) shall not cause any mechanical damage to the cable or clamping hardware. In addition, flexing of the optical fiber cable shall not cause an attenuation change greater than $\pm 0.05\text{ dB}$ per fiber, when tested with a source operating at $1550 \pm 20\text{ nm}$.
6. Subjecting the closure/cable interface to 10 cycles of torsional loading at ambient temperatures of $-18\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($0\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($104\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) shall not cause any mechanical damage to the cable or clamping hardware. In addition, torsional loading of the optical fiber cable shall not exceed allowable attenuation changes.
7. The closure shall not exhibit any mechanical damage after being subjected to a vertical drop from a height of 0.75 m (30 inches) at temperatures of $-18\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($0\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($104\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$).
8. The diameter of the optical fiber splice closure shall not permanently deform more than 10%, nor temporarily deform more than 20%, when it is compressed by a uniformly distributed load of 300 lbf. Additionally, the compressive load shall cause no mechanical damage to the closure or its contents.
9. The closure shall not exhibit any mechanical damage after being subjected to mechanical impact of 100 lbf (136 Nm) at temperatures of $-18\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($0\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($104\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$).
10. The closure central member clamp shall prevent movement (e.g. bowing, pistoning, or breaking) of the cable central member (CM) when the CM exerts a force of 100 lbf on the clamp.
11. Sealing components (gaskets, grommets, O-rings) used in a closure, shall not permit the entry of water into the closure after thermal aging at $90\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($194\text{ }^{\circ}\text{F} \pm 1.8\text{ }^{\circ}\text{F}$) for 720 hours (30 days).
12. The closure shall be capable of safe and proper assembly at temperatures of $0\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($32\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($104\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) using materials and procedures specified by the manufacturer.
13. The closure shall not exhibit any mechanical damage or corrosion following 30 days of severe temperature and humidity cycling from $65\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($150\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and 95% relative humidity to $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) and uncontrolled humidity. Additionally, at the midpoint of the temperature cycle, re-entry and re-assembly of the closure shall be done. If the closure has a hinged cover, it shall be flexed 25 times.
14. The closure shall show no evidence of water intrusion into the compartment containing fiber splices after it is immersed in water and subjected to 10 freeze/thaw cycles.
15. The splice closure shall show no evidence of water penetration following exposure to a 20-foot waterhead for a period of 7 days.
16. A closure shall show no evidence of corrosion following exposure to acidified saltwater for a period of 90 days.
17. The closure shall show no change in sealing ability after submersion in a specified chemical test fluid for 7 days. The mechanical integrity of the closure shall be confirmed by performing the compression and impact tests. The closure seal shall also be checked by performing the water immersion test. Additionally, samples of external, nonmetallic closure materials shall neither experience a change in weight greater than 10%, nor experience a reduction in tensile strength or elongation properties greater than 20%, after immersion in the chemical test fluid.
18. Samples of external, nonmetallic closure materials shall not have a reduction in tensile strength or elongation properties greater than 20% of their original value, after being exposed to a UV-B type ultraviolet light source with a peak emission at 313 nm for 2,160 hours (90 days).
19. Samples of polymeric closure materials shall not support fungus growth when tested per ASTM G 21. A rating of 0 is required.

2.5 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-D.

2.6 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-D and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in section 270554 "Identification of Communications Systems"

2.7 SOURCE QUALITY CONTROL

- A. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-D.3.
- B. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-D.3.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Fiber Backbone
 - 1. Inspect all raceway/duct bank systems in which fiber will be installed. Ensure all fittings are wrapped rigid conduit for fiber bend minimums. All manholes are 4 feet by 4 feet with cable management and round lids. All handholes must be double stacked or sized to accommodate fiber loops.
 - 2. Inspection: Determine that conduit, and any other equipment to be interfaced with the FO system is ready and has been tested before interfacing it with the FO system.
 - 3. Ensure that all cable reel tests have been performed and that the cable has passed all tests. Submit test results to the Architect for review and acceptance.
 - 4. All fiber submittals must be approved by the Architect in writing before any fiber installation or terminations can begin. Airport requires five business days from receipt of fiber submittals to review for comment. Non-approved submittals will be returned for re-submission.

3.2 FIBER INSTALLATION

- A. All system components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. All necessary interconnections, services, and adjustments required for a complete and operable FO system shall be provided.
- B. Contractor shall pump liquid from existing manholes used to install FO cables as may be required. When working in manholes, conform to all project confined workspace requirements.

- C. Install additional new pull strings with cable installation in existing or new duct bank and liner ducts.
- D. Do not use steel fish tapes in conduits or duct banks with existing cables if there is more than a 10 percent fill factor.
- E. Splices:
 - 1. No splices other than pigtail terminations shall be permitted unless the length of the cable being installed exceeds the maximum cable length available from the manufacturer and prior written approval is obtained from the Architect.
 - 2. Fiber optic splices shall be made by fusion splicing.
 - 3. Cable splices other than pigtails or other cable terminations shall be housed in a splice enclosure.
 - 4. All FO splices shall be field tested at the time of splicing. Splices shall have less than 0.2 dB loss.
 - 5. Sufficient cable shall be provided in each splicing location to properly rack and splice the cables.
 - 6. All cable ends shall be protected at all times with end caps except during actual splicing operations, means shall be provided to protect the unspliced portions of the cable from the intrusion of moisture and other foreign matter.
- F. Cable Installation:
 - 1. All fiber must be installed/protected in innerduct and conduit, unless otherwise noted on the drawings.
 - 2. Pulling fixtures shall be attached to the cable strength members. If indirect attachments are used, the grip diameter and length shall be matched to the cable diameter and characteristics. Attachment is used on cables having only central strength members; the pulling forces shall be reduced to ensure that the fibers are not damaged from forces being transmitted to the strength member.
 - 3. Continuously monitor pull line tension during cable pulling. Do not exceed the maximum tension as given by the cable manufacturer.
 - 4. The mechanical stress placed upon a cable during installation shall be such that the cable is not twisted or stretched.
 - 5. Use cable feeder guide between the cable reel and guide it into the duct or conduit as it is played off the reel.
 - 6. Inspect cable jacket carefully for defects as cable is played off the reel.
 - 7. Take precautions during installation to prevent the cable from being kinked or crushed.
 - 8. Do not exceed minimum bend radius of the cable.
 - 9. Hand feed and guide cable through each manhole and handhole. Apply additional lubricant at all intermediate manholes and handholes. Lubricant or pulling compounds used must not deteriorate conductor or insulations.
 - 10. When practicable, use center-pulling technique to lower pulling tension. Pull cable from the center point of the cable run towards the end termination points.
 - 11. Protect cable pulled out of a junction box or manhole from dirt and moisture by laying the cable on a ground covering.
 - 12. Any new underground fiber installation must have a one-inch, schedule 40 pvc pipe with a 10 gauge copper trace wire that lays on top of the new ductbank or pipe housing fiber and innerduct. Run trace wire continuous if possible. If continuous trace wire run is not possible, both ends of the trace wire shall be tied together under a ground lug supplied by the fiber installer and bolted to the side of the access enclosure.
 - 13. Any fiber run in existing conduits requires a copper trace wire. The trace wire will be a 10-gauge continuous run wire, allowing continuity measurement from end to end. If

continuous trace wire run is not possible, both ends of the trace wire shall be tied together under a ground lug supplied by the fiber installer and bolted to the side of the access enclosure.

G. Cable Installation Vertical Runs:

1. When possible, use gravity to assist in cable pulling.
2. Pull cable from top of run to bottom of run.
3. Hand pull if possible.
4. If machine assistance is required, monitor tension and do not exceed specific cable tension limits.
5. After installation, the vertical tension on the cable shall be relieved at maximum intervals of 100 feet using a split support grip.

H. Service Loops:

1. Each fiber optic cable shall have service loops of not less than 3 meters in length at each end.
2. Service loops in communications rooms shall be housed between equipment cabinets, unless otherwise specified.
3. Fiber optic cables terminating at video cameras shall have a service loop of a minimum of 1 meter at the camera end, and service loop shall be housed in the video junction box.
4. Service loops 50 feet in length (minimum) shall be provided for each FO cable at all handholes and manhole unless otherwise indicated on the contract drawings. Service loop lengths shall be in addition to any extra cable needed for splices made at the handhole or manhole.
5. Service loops in communication manholes must be neatly coiled and hung on cable management racks.
6. Per each communication manhole install four cable management racks, Model 3SR3 Saddle Rack as manufactured by Underground Devices Inc. of Northbrook, IL. (847) 205-9000 (or approved equal), with three saddles per rack each and to be mounted with stainless steel hardware and per manufacturers recommendations.
7. Service loops shall not be smaller than the minimum bend radius of the cable, pigtail or jumper which forms the service loop.

I. Fiber Breakout:

1. All fiber terminations shall utilize factory terminated pigtail connectors unless otherwise noted on the contract drawings. No field installed connectors shall be used without written approval by the Owner. If fiber breakout are required where CCH housings cannot be installed (i.e. within camera enclosures), the following shall apply:
 - a. All fiber cable ends shall have heat shrink installed at the transition from cable to loose tube or fan out kits.
 - b. On the back plane of a fiber optic patch panel or wall mounted distribution panel use a 25 inch fan-out assembly on loose tube fiber similar to the Corning P/N FAN-BT25-12. Not required for a tight buffer cable.
 - c. On the front plane (service-side) of a fiber optic patch panel or wall mounted distribution panel, a spider fan-out kit should be used on loose tube or tight buffered cable.

J. Fiber Marking:

1. All fiber cables shall be imprinted on the jacket at regular intervals of not more than five feet with the manufacturer's name, cable type and model number.
- K. Labeling:
1. All fiber cables where visible in each manhole, handhole, cable-tray, and junction box will be tagged with an orange wrap around cable identification wrap that is waterproof and hot stamped printed. Fiber optic cables in cable trays shall be tagged every 100 feet.
 2. All fiber innerduct where visible in each manhole, handhole, cable-tray, and junction box innerduct will be labeled with an orange wrap around identification wrap that is waterproof and hot stamped printed – identifying the cable content of the innerduct. Above ground conduits containing fiber must be labeled or tagged every 100 feet.
 3. Tag and label naming convention shall be in accordance with specification 27 05 54. The labeling format shall be identified and a complete record shall be provided to the Architect with the final documentation.
 4. Each cable shall be identified with the type of signal being carried and termination points.
 5. On individual fibers in fan-out tubing, a fiber label is required labeling fiber as 1, 2, 3 or blue, orange, green, etc.
- L. Surge Protection: All equipment connected to ac circuits shall be protected from power line surges. Equipment shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.
1. All communications equipment shall be protected against surges induced on any wireline connections of any communications circuit. All wireline cables and conductors serving as a communications circuit between a fiber optic transmitter or receiver and any other device shall have surge protectors installed at each end. Additional triple electrode gas surge protectors rated for the application on each wireline circuit shall be installed within 3 feet of the building cable entrance. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode using the following waveforms.
 - a. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
 - b. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes

3.3 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.

3.4 GROUNDING

- A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-D and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch 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.

3.5 IDENTIFICATION

- A. Comply with requirements in Section 270554 "Identification of Communications Systems".

3.6 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Visually inspect optical fiber jacket materials for NRTL certification markings.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and labeling of all components.
 - 3. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-D.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) Backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, 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 that calculated according to equation in TIA/EIA-568-B.1.
- B. Data for each measurement shall be documented in accordance with 270500 Common Work Results.
- C. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports. Test results must be submitted to the Owner for review and acceptance prior to use of the cable.

END OF SECTION 271323

SECTION 271500 - 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 6 twisted pair cable.
 - 2. Twisted pair cable hardware, including plugs and jacks.
 - 3. Cable management system.
 - 4. Grounding provisions for twisted pair cable.
 - 5. Source quality control requirements for twisted pair cable.
- B. Related Requirements:
 - 1. Section 280513 "Conductors and Cables for Electronic Safety and Security" 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. DA: Direct-Attach.
- C. EMI: Electromagnetic interference.
- D. FTP: Shielded twisted pair.
- E. F/FTP: Overall foil screened cable with foil screened twisted pair.
- F. F/UTP: Overall foil screened cable with unscreened twisted pair.
- G. IDC: Insulation displacement connector.
- H. LAN: Local area network.
- I. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- J. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- K. RCDD: Registered Communications Distribution Designer.

- L. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- M. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- N. S/FTP: Overall braid screened cable with foil screened twisted pair.
- O. S/UTP: Overall braid screened cable with unscreened twisted pairs.
- P. UTP: Unscreened (unshielded) twisted pair.

1.4 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between MDF/IDF, and the equipment outlet, 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/EIA-568-D.0 specifies that cable lengths depend on the application and the media chosen. All Ethernet applications are limited to 100 m on UTP media; therefore, the maximum permanent link length is 295 feet (95 m). Analog phone, fax, and ISDN applications are allowed to exceed this limitation.
 - 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 includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.
- D. Topology: Star Configuration

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 Architect.
 - 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. 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.

1.8 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 the field supervisor, who shall be present at all times when Work of this Section is performed at Project site.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Contractor shall be responsible for ensuring that 100% of all cables installed meet the specifications requirements.

1.10 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.

1.11 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Architect's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Description: 100-ohm, four-pair unshielded twisted pair (UTP), covered with a blue thermoplastic jacket for permanent cabling. Temporary cables as indicated on the contract documents shall have a yellow thermoplastic jacket.
 - 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA/EIA-568-D.1 for performance specifications.
 - 3. Comply with TIA/EIA-568-D.2, Category 6A.
 - 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.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-E.
- C. Grounding: Comply with TIA-607-D.

2.2 CATEGORY 6A TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6A cable at frequencies up to 500MHz.
- B. Manufacturers:
 - 1. Commscope
 - 2. Panduit
 - 3. Belden
- C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-D.2 for Category 6cables.
- D. Conductors: 100-ohm, minimum 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP).
- F. Cable Rating: Plenum.
- G. Jacket: Blue thermoplastic.

2.3 UTP CABLE HARDWARE

- A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-D.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher. All terminations shall use TIA/EIA 568B wire termination color coding.
- B. Patch Panels shall be in either modular 24 port or 48 port quantities.
- C. Jacks and Jack Assemblies shall be modular in nature and rated for the selected Category 6A cabling.

1. Patch Cables: Factory-made and terminated Category 6A cables for each Network Device to Patch Panel connections. Wall outlet locations shall be 4 meters in length for each outlet connection at user end; terminated with eight-position eight-connector (8P8C) modular plug at each end. The contractor shall provide an additional 10% of patch cables above what is indicated on the contract drawings., in addition to (100) 1 meter, (100) 3 meter, and (100) 4-meter patch cords of each color which shall be stored on site as spares. The quantities for specific lengths and colors of the spare patch cords shall be coordinated with the Architect.

2.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks and Jack Assemblies shall be modular Category 6A connectors.
- B. Workstation Outlets: Two and Four-port modular connector assemblies mounted in single faceplate. Public facing areas shall use metal faceplates, while back of house and other non-public areas shall use plastic. Refer to detail drawings for configurations.
 1. Plastic Faceplate: High-impact plastic.
 2. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."
 3. For use with snap-in jacks accommodating any combination of F/UTP, UTP, optical fiber, and coaxial work area cords.
 4. Machine printed, in the field, using adhesive-tape label.
 5. Snap-in, clear-label covers and machine-printed paper inserts.
 6. Blank icons for unused ports
- C. Protector Blocks: Used for protection of outdoor station cables.
 1. Configuration of outdoor station cable protectors:
 - a. One 4-Pair UTP Category 6A solid-state protector
 - b. Shall comply with TIA/EIA standards for Category 6A performance.
 - c. Shall be UL listed.

2.5 ACCEPTABLE MANUFACTURERS

1. ITW Linx for outdoor station cable protectors.
2. Architect approved equal.

2.6 CABLE MANAGEMENT SYSTEM

- A. Description: Computer-based cable management system, with integrated database and graphic capabilities.
- B. Manufacturers:
 1. CommScope
 2. Panduit
 3. Chatsworth
- 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.
- 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.

2.7 IDENTIFICATION PRODUCTS

- A. Comply with requirements in Section 270554 "Identification for Communications Systems".

2.8 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-D.

2.9 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test twisted pair cables according to TIA-568-D.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Cabling and its installation shall comply with authority having jurisdiction (AHJ) and applicable regulations.
- B. The cable shall not be subjected to pulling tension exceeding the pulling strength rating of the cable.
- C. The cable bend radius shall be greater than or equal to the minimum bend radius requirement during and after installation.
- D. All bundles of cabling in the final installation shall use Velcro to hold the cabling together. At no point will zip-ties be in place along the horizontal cabling for the final installation.
- E. 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 pathways 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 270534 "Pathways for Communications Systems".
- F. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- G. Wiring within Enclosures:
1. Bundle, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 2. Utilize the appropriate pathways within the enclosure for any horizontal cable terminations.
 3. Install conductors parallel with or at right angles to sides and back of enclosure.
 4. Terminations within smaller enclosures (under 12x12" sizes) shall have their slack and biscuit termination block neatly bundled with Velcro cable ties.
- H. Maintain compatibility with the environmental conditions by means of enhanced cabling components, protection, separation, and isolation applicable to each area; refer to Annex F of ANSI/TIA-568-D.0.

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 270528.29 "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-D.0, TIA-568-D.1, and TIA-568-D.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 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 from communications equipment room.
 8. Cables shall 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.
 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 de-reeling. Heat lamps shall not be used for heating.
 13. In the communications equipment room, install a 10-foot- 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 above ceilings by cable supports not more than 60 inches 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 long not less than 12 inches in diameter below each feed point.
- E. Group connecting hardware for cables into separate logical fields.

3.4 SEPARATION FROM EMI SOURCES:

- A. Comply with BICSI TDMM, TIA-569-C, and NFPA 70 for separating unshielded copper balanced twisted pair cable from potential EMI sources, including electrical power lines and equipment.
- B. Zero pathway separation distance is permitted when the electrically conductive telecommunications cables, the power cables, or both are enclosed in metallic pathways that meet the following conditions:
 1. The metallic pathway(s) completely enclose the cables and are continuous;

2. The metallic pathway(s) are properly bonded and grounded per ANSI/TIA-607-B; and
 3. The walls of the pathway(s) have a minimum thickness 1 mm (0.04 in) nominal if made of steel or 1.5 mm (0.06 in) nominal if made of aluminum.
- C. No separation is required between power and telecommunications cables crossing at right angles.
- D. Separation between Unshielded Twisted Pair (U/UTP, F/UTP) in nonmetallic raceways and power wiring:
1. 120/230 Vac, 20 A
 - a. 1-15 circuits: Minimum 2" separation from UTP
 - b. 16-30 circuits: Minimum 4" separation from UTP
 - c. 31-60 circuits: Minimum 8" separation from UTP
 - d. 61-90 circuits: Minimum 12" separation from UTP
 - e. ≥91 circuits: Minimum 24" separation from UTP
 2. 120/230 Vac, 100 A
 - a. 1 circuit: Minimum 4" separation from UTP
 - b. 2 circuits: Minimum 8" separation from UTP
 - c. 3 circuits: Minimum 12" separation from UTP
 - d. ≥4 circuits: Minimum 24" separation from UTP
 3. 480 Vac, 100 A
 - a. 1 circuit: Minimum 12" separation from UTP
 - b. ≥ circuits: Minimum 24" separation from UTP
 4. 277 Vac, 20A
 - a. 1-15 circuits: Minimum 4" separation from UTP
 - b. 16-30 circuits: Minimum 8" separation from UTP
 - c. 31-60 circuits: Minimum 12" separation from UTP
 - d. ≥ 61 circuits: Minimum 24" separation from UTP
- E. Separation between Screened Twisted Pair (ScTP, S/FT, S/STP, S/FTP) in nonmetallic raceways and power wiring:
1. 120/230 Vac, 20 A
 - a. 1-15 circuits: Minimum 0" separation from ScTP
 - b. 16-30 circuits: Minimum 2" separation from ScTP
 - c. 31-60 circuits: Minimum 4" separation from ScTP
 - d. 61-90 circuits: Minimum 6" separation from ScTP
 - e. ≥91 circuits: Minimum 12" separation from ScTP
 2. 120/230 Vac, 100 A
 - a. 1 circuit: Minimum 2" separation from ScTP
 - b. 2 circuits: Minimum 4" separation from ScTP
 - c. 3 circuits: Minimum 6" separation from ScTP
 - d. ≥4 circuits: Minimum 12" separation from ScTP

3. 480 Vac, 100 A
 - a. 1 circuit: Minimum 12" separation from ScTP
 - b. ≥ circuits: Minimum 24" separation from ScTP
 4. 277 Vac, 20 A
 - a. 1-15 circuits: Minimum 2" separation from ScTP
 - b. 16-30 circuits: Minimum 4" separation from ScTP
 - c. 31-60 circuits: Minimum 6" separation from ScTP
 - d. ≥ 61 circuits: Minimum 12" separation from ScTP
- F. Separation between Shielded Twisted Pair (STP, F/STP) in nonmetallic raceways and power wiring:
1. 120/230 Vac, 20 A
 - a. 1-15 circuits: Minimum 2" separation from STP
 - b. 16-30 circuits: Minimum 4" separation from STP
 - c. 31-60 circuits: Minimum 8" separation from STP
 - d. 61-90 circuits: Minimum 12" separation from STP
 - e. ≥ 91 circuits: Minimum 24" separation from STP
 2. 120/230 Vac, 100 A
 - a. 1 circuit: Minimum 4" separation from STP
 - b. 2 circuits: Minimum 8" separation from STP
 - c. 3 circuits: Minimum 12" separation from STP
 - d. ≥4 circuits: Minimum 24" separation from STP
 3. 480 Vac, 100 A
 - a. 1 circuit: Minimum 12" separation from STP
 - b. ≥ 1 circuit: Minimum 24" separation from STP
 4. 277 Vac, 20A
 - a. 1-15 circuits: Minimum 4" separation from STP
 - b. 16-30 circuits: Minimum 8" separation from STP
 - c. 31-60 circuits: Minimum 12" separation from STP
 - d. ≥ 61 circuits: Minimum 24" separation from STP

3.5 FIRESTOPPING

- A. Provide fire rated penetration systems similar to "Flame Safe" as detailed in the drawings.
- B. Comply with requirements in Section 078413 "Penetration Firestopping."
- C. Comply with TIA-569-E, Annex A, "Firestopping."
- D. Comply with "Firestopping Systems" Article in BISC's "Telecommunications Distribution Methods Manual."

3.6 GROUNDING

- A. Comply with TIA-607-D and NECA/BICSI-607 and BICSI Telecommunications Distribution Methods Manual Recommended Practices
- B. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.
- C. 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-D. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
 - 1. Administration Class: Class 2
 - 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-D for Class 2 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.

3.8 FIELD QUALITY CONTROL

- A. Refer to specification 27 05 00 "Common Work Results for Communications Systems" for further details on testing of horizontal cabling.

END OF SECTION 271500

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.
- B. Division 08 Specifications
- C. Division 11 Specifications
- D. Division 26 Specifications
- E. Division 27 Specifications
- F. Division 28 Specifications

1.2 SUMMARY

- A. Section includes:
 - 1. Electronic safety and security equipment coordination and installation.
 - 2. Common electronic safety and security installation requirements.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.3 REFERENCES

- A. Specific reference in specifications to codes, rules, regulations, standards, manufacturer's instructions, or requirements of regulatory agencies shall mean the latest printed edition of each in effect at the date of contract unless the document is shown dated.
- B. Conflicts:
 - 1. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.
 - 2. Contractor is responsible for notifying the Owner and providing a recommended resolution immediately upon identification of any conflicts.

1.4 COORDINATION

- A. Contractor shall coordinate arrangement, mounting and support of electronic safety and security equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at required slope.
 4. To assure connecting raceways, cables, wireways, cable trays and busways will be clear of obstructions and of the working and access space of the other equipment.
- B. Contractor shall coordinate installation of required supporting devices.
- C. Contractor shall coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- D. Contractor shall coordinate location of equipment for electronic safety and security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Panels and Frames."
- E. Contractor shall coordinate and perform integration between the electronic safety and security monitoring and control system, access control systems, and video surveillance systems.

1.5 MINIMUM QUALIFICATIONS

- A. General:
1. The intent of these specifications is to ensure the systems described in this division are provided and installed by a technically experienced Security Electronics Contractor (SEC) and, further, that all security electronic work is fully coordinated between the various specified sub-systems by a single SEC who is technically qualified as described herein.
 2. All personnel performing any installation, configuration, or oversight of the Electronic Safety and Security Systems implementation shall hold the appropriate certifications, training, and experience requirements as specified in this section. In no instance shall any contractor's staff perform any work on the Electronic Safety and Security System without the appropriate training and certifications.
 3. The Owner reserves the right to reject the Contractor's use of installers which meet the stated minimum requirements but in the opinion of the Owner does not meet the Owner's standard and/or industry standard of satisfactory workmanship.
 4. Installation Contractors shall have been in business a minimum of five (5) years performing similar work as described within these specifications.
- B. Electronic Safety and Security Contractor Minimum Qualifications:
1. The contractor shall have been in the business of designing, installing, and maintaining systems at qualified sites for a minimum of five (5) years. In addition, the contractor shall demonstrate experience as the primary entity responsible for the overall design and implementation of systems similar to work described here.
 2. Contractors for current validation, desiring to bid the project shall send in a qualification package to the AE a minimum of 2 weeks prior to the bid date detailing that the contractor explicitly meets or exceeds the following qualifications:
 - a. The SEC shall have a company license number issued by the state, which signifies they are approved to do security work in the state (if applicable).

- b. The SEC shall have successfully completed a minimum of 5 projects similar to size and complexity to this project. These projects must have been designed to use industrial Programmable Logic Controllers (PLC's) and Graphic User Interface (GUI) control stations as described in this specification and applied in a state or government facility application. The 5 projects should be in comparable size, scope, and price to this project. This project is requiring a "Single Source Responsibility" format requiring complete installation by full time employed employees of the SEC.
- c. For each of these projects the following information shall be listed:
 - 1) General Contractor (GC) company name, contact person name and phone number for each project listed, the GC will be contacted to inquire on the professionalism and performance of the SEC during the construction process.
 - 2) Brand of PLC, GUI, Audio, Video, Access Control (if applicable) and Networking equipment used.
 - 3) Value of each subsystem and total contract price.
 - 4) Technically describe how each system was integrated together as one complete system.
 - 5) Provide Owner contact person name and phone number at each submitted project site that can confirm that the SEC's systems are performing free of anomalies and defects in an acceptable manner to date.
 - 6) List the names and roles of SEC employees who performed work on the submitted projects.
- d. The SEC shall provide the following:
 - 1) The SEC shall provide a notarized statement from the SEC's president or officer, stating intent to: "comply fully with the requirements of this specification and to hold harmless the Architect, Engineer and Owner from omissions of a casual nature that would be considered to be an implied requirement for a fully operational security electronics integrated system."
 - 2) Provide a list of all outstanding, past judgments or lawsuits against the company or Owner under their current name or any previous name or business entity.
 - 3) Organizational chart with the resumes of a key individual from each department who will be assigned to this project (management, operations, engineering, programming, fabrication, etc.).
 - 4) The work of this division shall be managed and supervised by a full-time site project superintendent. Provide resumes for each potential superintendent who will be dedicated to this project. Each candidate should have the following minimum qualifications:
 - a) Experience in the applications engineering, installation, and supervision of similar construction projects both in similar scope and system complexity for a minimum of 10 years.
 - b) Full time employee of the submitting SEC.
 - c) Have a working knowledge of all systems installed under this division.
 - d) Project superintendent shall be on site full time through duration of construction.

- 5) Provide a narrative description of all software to be utilized, network types, and interfaces with other systems. Any custom software that is to be developed by the SEC needs to be described in detail.
 - 6) Provide written confirmation, "Software Assurance Letter", that at the completion of the Factory Acceptance Test, the submitting systems SEC will provide to the Owner, at no charge, the complete ladder-logic program used on the project to date, fully commented, the complete list of scripts and routines used in the GUI Security Electronics Control Station package fully commented. The letter must also state the source code of any custom or proprietary DLL, EXE, NET or software module written by the submission systems SEC will not be used for the project. At the completion of the project, before acceptance from the Owner and the final retainage payment, the systems SEC will provide the final, fully commented documentation, listed above, for the project.
 - 7) A letter from the SEC's Surety Company reflecting the Surety Company's history and experience with the SEC and the current bonding limit for the last 5 years.
- C. Where the SEC is a branch office or other division of a larger organization, the qualifications of the branch office or other division shall meet the requirements of the contract documents.
- D. Systems SEC's who do not meet these specifications or do not have an acceptable reputation of good service shall not bid this project.
- E. Project Conditions:
1. Examine Contract Document to determine how other work will affect execution of electronic systems work.
 2. Make arrangements for and pay for necessary permits, licenses, and inspections if required.
 3. Determine and verify locations of all existing utilities on site.
 4. Provide covering and shielding for all equipment to protect from damage.
 5. Repair, restore or replace damaged, corroded and rejected items where applicable.

1.6 CONSTRUCTION SUBMITTALS

- A. Construction submittals shall be provided in accordance with Division 1 requirements. Refer to individual Division 28 specification sections for all required equipment and system submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Where specific equipment and/or manufacturers are identified as the provider of a specific product or product line, no substitutions shall be allowed without prior written approval by the Owner.
- B. Where a specific make and model number is identified in the specifications or drawings, the Contractor shall provide the most current version of the equipment or item.

- C. Refer to individual Division 28 specifications for specific manufacturer requirements.

2.2 PROCUREMENT

A. Contemporary Equivalent

1. Due to the rapid advancement and antiquation of electronic technology, the contractor supplied hardware, including any software/firmware, shall be the “contemporary equal” of the specified hardware including software/firmware. The following requirements shall be met:
 - a. Contemporary equal shall be based on a comparison of technology at the time of publication of specification to the technology at the time of ordering the equipment for each construction bid package/phase.
 - b. Hardware shall be ordered as close to the actual installation date for a given phase as reasonable (i.e., latest responsible date).
 - c. Hardware equivalence shall be based on both technical equivalence and operational equivalence.
 - d. Contemporary technical equivalence shall be based on device performance specifications.
 - e. Contemporary operational equivalence shall be based on industry standards and function.
 - f. In instances where the specifications and/or contract drawings depict a specific manufacturer and/or part number, the contemporary technical and operational equivalent product shall be from the same manufacturer.

- B. In no instance shall any product be submitted that has been identified by the manufacturer as being “End of Life” (EoL) within one (1) year of the product submittal date. EoL is defined as the date when the manufacturer determines that the product will no longer be manufactured or supported by the manufacturer. Where products are identified as EoL, the submitted product shall be the manufacturer’s replacement product that adheres to the contemporary technical and operational equivalent as defined above.
- C. All active electronic equipment (computers, servers, cameras, networking switches, etc.) shall be submitted for review to the architect no earlier than 120 calendar days prior to installation. Where long lead items (greater than 120 calendar days) are identified, the Contractor shall submit a request in writing, along with evidence from the manufacturer that the item’s lead time is greater than 120 calendar days. Electronic products that are identified as long-lead items may be excepted if they are identified in the initial submittal schedule. Long-lead electronic product submittals may be made based on the estimated lead time, plus 60 calendar days.
- D. All passive communications related equipment (copper, fiber, equipment cabinets, etc.) shall be submitted for review to the architect no earlier than 180 calendar days prior to installation. Where long lead items (greater than 180 calendar days) for procurement are identified, the Contractor shall submit a request in writing, along with evidence from the manufacturer that the item’s lead time is greater than 180 calendar days.

2.3 SOFTWARE

- A. The Contractor shall prepare and submit documentation verifying the version of all software provided by the Contractor, and providing confirmation that the proposed software version is in compliance with the specification requirements, the system requirements, and the requirements for integration with other software associated with the system, whether new or existing.

2.4 LICENSING

- A. Provide all required licenses for the equipment and software provided.
- B. Any additional required software licenses shall be identified and supplied by the contractor. Additional licenses must be verified by the Owner's Personnel before purchasing.
- C. All software licenses provided under Division 28 shall be registered in the name of the owner/user, not the contractor.
- D. All software licenses shall be perpetual.
- E. Fully licensed software shall be provided for use in the live operational environment as well as testing and training facilities.
- F. Hardware changes shall not affect the licenses supplied.
- G. It shall be possible to replace any part of the hardware without impacting the working of any license keys.
- H. License Key issues shall never cause an outage to a system that is in the live operational environment.
- I. Contractor shall provide licensing in accordance with the individual Division 28 specification sections.

PART 3 - EXECUTION

3.1 GENERAL

- A. Comply with NECA 1.
- B. All equipment shall be installed in a professional and workmanlike manner. All methods of construction that are not specifically described or indicated in the project specifications or drawings shall be subject to the control and approval of the Owner. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified, and subject to approval.
- C. Contractor shall validate installation conditions expediently, reporting any potential conflicts immediately to the architect for coordination of resolution.

- D. The Owner reserves the right to observe all equipment, hardware, cabling and ancillary equipment installations. The contractor shall provide a schedule defining installation plans to the Owner no less than 30 calendar days in advance of commencing work and shall provide the Owner updates of any changes at least ten calendar days in advance.
- E. System Programming: The programming of all equipment shall be by the contractor, using requirements provided in the project manual.
- F. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- G. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- H. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

3.2 INSTALLATION

- A. Install all Electronic Safety and Security Systems components in accordance with the project drawings and specifications, manufacturer's installation/configuration procedures, BICSI recommended practices, and ANSI/TIA/EIA standards.
- B. Conduit shall be installed in compliance with the division 26 specifications. Conduit shall, wherever possible, be installed embedded in walls and concealed above ceilings.
 - 1. In areas where conduit must be installed exposed and surface mounted below 12' AFF, conduit shall be GRC type and shall be secured using two-hole straps on 18" centers with security torx hardware.
- C. Contractor shall match color type and size of faceplates with adjacent electrical devices.
- D. Coordinate all work with the Owner and the approved project schedule.

3.3 TESTING, INSPECTION, AND ACCEPTANCE

- A. The installation of all Electronic Safety and Security Systems components shall be fully tested and inspected prior to acceptance by the Owner. The following provides the general approach to testing, inspection, and acceptance. Refer to individual specification sections and contract drawings for further requirements.
- B. Electronic Safety and Security Systems Testing, Inspection, and Acceptance:
 - 1. The Contractor shall prepare, submit for review, and execute test plans to demonstrate system completion and performance. Except as otherwise specified, the Contractor shall test all components, connections, and subsystems comprising the total system as described in the contract documents as a complete operational system. The phases of testing and acceptance shall include the following:

- a. Component / Unit testing (prior to installation)
 - b. Proof-of-Concept Test / Factory Acceptance Testing
 - c. Functionality and Performance Testing (preceded by system installation)
 - d. Endurance Testing (preceded by successful functionality and performance testing)
2. Testing shall demonstrate compliance with the specifications and the contract document requirements.
3. The Contractor shall coordinate all testing activities with the owner.
4. The Contractor shall provide a minimum of ten calendar days' notice prior to commencement of formal testing activities.
5. Test Plan/Procedure: The Contractor shall provide electronic copies of the test plan/procedures for each testing phase for the review and approval of the Owner. The test plan for each phase of testing shall detail the objectives of all tests. The tests shall clearly demonstrate that the system and its components fully comply with the requirements specified in the contract drawings and specifications. Test plans shall contain at a minimum:
 - a. Functional procedures including use of any test equipment.
 - b. Test equipment is to be identified by manufacturer and model.
 - c. Interconnection of test equipment and steps of operation shall be defined.
 - d. Test records shall include test equipment serial number, calibration date and calibration certification of test equipment. All calibrations shall be current.
 - e. Expected results required to comply with specifications.
 - f. Traceability matrix referencing Specification requirements with specific test procedures.
 - g. Record of test results with witness initials or signature and date performed.
 - h. Pass or fail evaluation with comments.
6. The test procedures shall provide conformity to all Specification requirements. Satisfactory completion of the test procedure is necessary as a condition of system acceptance.
7. The contractor shall review all formal test procedures prepared by the Contractor and deliverable under the contract to assure the tests cover all requirements and that there is a conformity between the conducted test, the test results and Specification requirements.
8. The Contractor shall provide the Owner the opportunity(s) to participate in any or all of tests.
9. Test Reports: The Contractor shall prepare, for each test, a test report document that shall certify successful completion of that test. An electronic copy of the test report shall be submitted to the Owner for review and acceptance. The test report shall contain, at a minimum:
 - a. Commentary on test results;
 - b. A listing and discussion of all discrepancies between expected and actual results and of all failures encountered during the test and their resolution;
 - c. Complete copy of test procedures and test data sheets with annotations showing dates, times, initials, and any other annotations entered during execution of the test;
 - d. Signatures of persons who performed and witnessed the test.

10. Test Resolution: Any discrepancies or problems discovered during these tests shall be corrected by the Contractor at no cost to Owner. The problems identified in each phase shall be corrected and the percentage of the entire system re-tested as determined by the architect before any subsequent testing phase is performed.
11. Unit / Component testing:
 - a. Upon receipt of system components to be installed, and prior to installation in the field, the Contractor shall perform unit testing to ensure the components are operating as intended.
12. Factory Acceptance Testing / Proof of Concept Testing:
 - a. Test Setup Equipment: Equipment shall be actual products or identical models of products to those designated to be delivered and installed at the site. The following equipment shall be setup and used for conducting pre-delivery test:
 - 1) Operator equipment associated with system.
 - 2) End devices and displays associated with system.
 - 3) Software associated with system.
 - 4) Administrative console equipment.
 - b. Preparation: Ensure that development of system is complete, required approvals of submittals have been obtained, and sufficient equipment procured to completely demonstrate and test system.
 - c. Time: Prior to deployment of any equipment to the field. Conduct on weekdays during standard business working hours.
 - d. Location: Contractor's manufacturing facility.
 - e. Items to be tested shall be set up and performance verified prior to arrival of representatives of Owner at test site.
 - f. Test: The purpose is to test the complete system and demonstrate that all specified features and performance criteria are met. All requirements of the specification shall be tested including, but not limited to:
 - 1) Functionality including reporting and response.
 - 2) System capacity.
 - 3) Hardware interaction.
 - 4) Hardware and software interaction.
 - 5) Demonstrate report generation.
 - g. Acceptance: Acceptance of system to perform sufficiently and provide specified functions shall be determined by Owner witnessing the factory acceptance test.
 - h. Acceptance Criteria: Performance of system shall equal or exceed criteria stated in individual specification sections.
 - i. If system does not perform satisfactorily, the Contractor shall make corrections and modifications and schedule new test.
 - j. Travel related expenses of Owner to attend pre-delivery test shall be borne by Contractor if testing is conducted more than 50 miles from project site. Travel related expenses to attend re-testing shall be borne by Contractor.

- k. Completion:
 - 1) At successful completion of test, dismantle equipment so as to prevent damage. Replace all defective or worn items.
 - 2) Re-pack in original containers all equipment to be delivered to site for installation. Mark on containers that items were used in factory test.
- l. Reporting:
 - 1) Record all test procedures and results.
 - 2) Submit report to Owner
- 13. Functionality and Performance Testing:
 - a. Functionality testing will include the software and hardware components of the system and demonstrate that the specified features and performance criteria are met once all components have been installed. All major requirements of the Specifications shall be tested including:
 - 1) Operational testing of the head-end system
 - 2) Operational testing of end user devices
 - 3) Functionality and response of core system and subsystems
 - 4) A Failure Recovery test procedure shall be conducted. The Failure Recovery will include a full system failure and recovery procedures.
 - 5) Data interaction
 - 6) System capacity
 - 7) Hardware interaction
 - 8) Hardware and software interaction
 - 9) Integration Interfaces
 - 10) Demonstrate report generation
 - b. Schedule test with the Owner providing a minimum of ten calendar days' notice prior to performance. Do not begin testing until:
 - 1) Factory Acceptance Testing/Proof of Concept testing has been successfully completed.
 - 2) All required system elements have been installed and individually and jointly tested to ensure they are operating properly.
 - 3) Written permission from the Owner has been received.
 - c. Acceptance: Acceptance of system to perform sufficiently and provide specified functions shall be determined by the Owner.
 - 1) Acceptance Criteria: Performance of system shall equal or exceed criteria stated in individual Specification sections.
 - 2) If system does not perform satisfactorily, the Contractor shall make corrections and modifications and schedule new test with Owner.
 - 3) Completion: Functionality and performance test shall be complete when testing or retesting of each component has produced a positive result and has been approved in writing by the Owner.

d. Reporting:

- 1) Record all test procedures and results.
- 2) Submit report to Owner.

e. Termination:

- 1) Test shall be terminated by the Owner when:
 - a) Individual components, subsystems, or the common use system fail to perform as specified.
 - b) It is determined that the system is missing components or installation is not complete.
 - c) Upon termination, corrective work shall be performed and the Test rescheduled with the Owner.
- 2) Re-testing shall be performed by Contractor at no additional expense.
- 3) Contractor shall continue to perform corrective actions and re-test until system passes or the Owner terminates testing.

14. Substantial Completion:

- a. Once system is fully installed, operational, in use and training is complete, the system will be considered substantially complete.
- b. Endurance Testing shall not commence until written notice of Substantial Completion is received.

15. Endurance Testing:

a. General:

- 1) Provide personnel to operate/monitor the system 24 hours per day, including weekends and holidays during Endurance Testing.
- 2) Start test after:
 - a) Successful completion of Functionality and Performance Testing.
 - b) Training as specified has been completed.
 - c) Correction of deficiencies has been completed.
 - d) Receipt of written notice of Substantial Completion and approval to commence Endurance Testing is received from the Owner.
- 3) Monitor all systems during Endurance Testing. Coordinate monitoring with the Owner.
- 4) Recording: Record data on approved forms so as to provide a continuous log of systems performance. Include:
 - a) Date and time for all entries.
 - b) Name of individual making entry.
 - c) Environmental conditions.
 - d) Description of all alarm annunciations, responses, corrective actions, and causes of alarms. Classify as to type of alarm.
 - e) Description of all equipment failures, including software errors.

- f) Description of all maintenance and adjustment operations performed on system.
- g) Daily and weekly tabulations.
- 5) Entries of performance data shall be reviewed by the Owner.
- 6) Owner may terminate testing at any time when the system fails to perform as specified. Upon termination of testing the Contractor shall commence an assessment period as described in Stage II.

b. Testing:

- 1) Stage I - Initial Phase Testing:
 - a) Time: 24 hours per day for 10 consecutive calendar days (8 hr./day Contractor system engineer available onsite during testing period)
 - b) Make no repairs during this stage unless authorized in writing by the Owner.
 - c) If system experiences no emergency, critical failures, or recurring operational failures (defined as same operational failure more than 3 times during 10 days), proceed to Stage III - Final Testing.
- 2) Stage II - Initial Phase Assessment:
 - a) After conclusion of Stage I, or terminating of testing, identify all failures, determine causes, and repair. Submit report explaining: Nature of each failure, corrective action taken, results of tests performed to verify corrective action as being successful, and recommended point for resumption of testing.
 - b) After submission of report, schedule review meeting at job site. Schedule date and time with the Owner.
 - c) At review meeting, demonstrate that all failures have been corrected by performing verification tests.
 - d) Based on report and review meeting, the Owner will direct Contractor to repeat Stage I, restart Stage I, or proceed to Stage III - Final Testing.
- 3) Stage III - Final Phase Testing:
 - a) Time: 24 hours per day for 15 consecutive calendar days (may be monitored remotely).
 - b) Make no repairs during this stage unless authorized in writing by the Owner.
 - c) If system experiences no emergency, critical failures, or recurring operational failure (defined as same operational failure 3 times in 24 hours or more than 7 times during 15 days), proceed to Stage III – Final Phase Assessment.
- 4) Stage IV - Final Phase Assessment:
 - a) After conclusion of Stage III or termination of testing, identify all failures, determine causes, and repair. Submit explaining the nature of each failure, corrective action taken, results of tests performed, and recommended point for resumption of testing.

- b) After submission of report schedule review meeting at job site. Schedule date and time with the Owner.
- c) At review meeting, demonstrate that all failures have been corrected by performing verification tests.
- d) Based on report and review meeting, the Owner will approve Endurance Test or direct Contractor to repeat all or part of Stages III and IV.

c. Adjustment, Correction, and Maintenance

- 1) During Endurance Testing make adjustments and corrections to system only after obtaining written approval of the Owner
- 2) During Endurance Testing, perform required maintenance on systems including provision of replacement parts.

d. Final Inspection And Acceptance

- 1) After Endurance Testing is complete, review tabulated records with the Owner.
- 2) Contractor will not be responsible for failures caused by:
 - a) Outage of main power in excess of backup power capability provided that automatic initiation of all backup sources was accomplished and automatic shutdowns and restarts of systems performed as specified.
 - b) Failure of any Owner furnished power, communications, and control circuits provided failure not due to Contractor furnished equipment, installation, or software.
 - c) Failure of existing Owner equipment provided failure not due to Contractor furnished equipment, installation, or software.
 - d) When performance of system does not fall within the above parameters, determine cause of deficiencies, correct, and retest.
- 3) Submit final report of Endurance Testing containing all recorded data.

16. Final System Acceptance:

- a. Upon successful completion of Endurance Testing, and completion with all Division 0/1 requirements, written notice of Final System Acceptance will be provided by the Owner.
- b. Final System Acceptance will mark the beginning of the system Warranty (and Maintenance if selected) period.

3.4 TRAINING

- A. Refer to Division 1 specifications for overall training requirements.
- B. Refer to individual Division 28 specifications for systems and component training requirements.

3.5 SPARE PARTS

1. The Contractor shall furnish a bill of materials, catalogue numbers, unit prices, and a list of local distribution sources for replacement parts. Required spares shall be on-site, inventoried, and turned over to the Owner at the time of final system acceptance to be used during the warranty period. Materials shall be replaced when they are placed into service and the spare parts inventory shall be verified at the end of the warranty period to ensure the required quantities are in place. Where not specified in the contract drawings or specifications, a minimum of five (5) percent of spare components shall be provided for all system end devices, and additionally five (5) percent of all components that are prone to routine maintenance.

3.6 PROJECT CLOSEOUT

- A. Prior to project closeout, all components shall be tested and accepted by Owner, and all required as-built documentation shall be submitted.
- B. In addition to all Division 1 specification requirements, the project closeout shall require the following:
 1. All system test records submitted and accepted by Owner
 2. Field inspections performed by the Owner to ensure all components have been installed correctly.
 3. All project punch list items have been completed.
 4. As-built cable records, drawings, and cable management information has been submitted and accepted by Owner.
 5. All applicable Owner provided GIS documentation forms to be filled out.

PART 4 - WARRANTIES

- A. General: The Contractor shall provide a joint written warranty by the manufacturer(s) and the installer(s) of all equipment and services on a single document. The warranty shall warrant complete installation of the equipment, system, and software (where applicable) to be free from defects in materials and workmanship for a period of no less than twelve (12) months or for such longer times as may be set forth with respect to specific warranties contained in the Specification or the manufacturer's standard warranty, whichever is longer.
- B. Warranties commence on the date of Substantial Completion unless otherwise provided for in the Contract
- C. The Contractor shall warrant that the system will conform to its description and any applicable specifications and shall be of good quality for the known purpose for which it is intended. This warranty shall be in addition to any standard warranty or service guarantee given by the Contractor to the Owner's designated representative.
- D. The Owner will be the named and recorded warranty holder for all equipment.
- E. Equipment provider shall be responsible for all expenses, coordination, and arrangements required to ship defective equipment back to the manufacturer from the site and from manufacturer back to the site, during the manufacturer's warranty.

END OF SECTION 280500

SECTION 280513 - CONDUCTORS AND CABLES 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.
- B. Division 27 Specifications

1.2 SUMMARY

- A. All fiber optic and copper category UTP cabling is provided and specified under Division 27. All other cabling including door control and monitoring and discrete control circuit cabling, such as elevator interface, are specified herein. Copper patch panels are specified under Division 27 and are provided under Division 28 only as noted on the TY series drawings.
- B. Section Includes:
 - 1. RS-232 cabling.
 - 2. Control-voltage cabling.
 - 3. Control-circuit conductors.
 - 4. Identification products.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. IDC: Insulation displacement connector.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- E. RCDD: Registered Communications Distribution Designer.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of electronic safety and security cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Installation data for UTP cables as specified in TIA 569-C-1.
 - 2. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.
- B. Shop Drawings:
 - 1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 2. Cabling administration drawings and printouts.
 - 3. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 - 4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.8 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.
 - 2. Test each pair of UTP cable for open and short circuits.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 UTP CABLE HARDWARE

- A. Manufacturers: Subject to compliance with the Division 27 specifications and requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Commscope
 - 2. Panduit Corp.
- B. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
- C. Patch Panels: For Category 6A. Provide connectivity for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks.

2.3 RS-232 CABLE

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. West Penn Wire
 - 2. Belden
 - 3. General Cable
- B. Standard Cable: NFPA 70, Type CM.
 - 1. Multi-conductor, No. 22 AWG, stranded (7x30) tinned copper conductors. Conductor count per the application.
 - 2. Polypropylene insulation.
 - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 - 4. PVC jacket.
 - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. Flame Resistance: Comply with UL 1581.
- C. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Multi-conductor, No. 22 AWG, stranded (7x30) tinned copper conductors. Conductor count per the application.
2. PE insulation.
3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. Fluorinated ethylene propylene jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.4 CONTROL-VOLTAGE CABLE

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
1. West Penn Wire
 2. Belden
 3. General Cable
- B. Paired Cable: NFPA 70, Type CMG.
1. One pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
 2. PVC insulation.
 3. Unshielded.
 4. PVC jacket.
 5. Flame Resistance: Comply with UL 1581.
- C. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1. One pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
 2. PVC insulation.
 3. Unshielded.
 4. PVC jacket.
 5. Flame Resistance: Comply with NFPA 262.

2.5 CONTROL-CIRCUIT CONDUCTORS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
1. West Penn Wire
 2. Belden
 3. General Cable
- B. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.
- C. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway [power-limited cable, complying with UL 83, concealed in building finishes power-limited tray cable, complying with UL 83, in cable tray.

2.6 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Panduit
 - 2. Brady
 - 3. Hellerman Tyton
- B. 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.
- C. Comply with requirements in Section 270553 "Identification for Communications Systems."

2.7 SOURCE QUALITY CONTROL

- A. Factory test UTP and optical-fiber cables on reels according to TIA-568-D.1.
- B. Factory test UTP cables according to TIA-568-D.2.
- C. Factory test multimode optical fiber cables according to TIA-526.14-B and TIA-568-D.3.
- D. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results. Structural Return Loss shall be less than 20 db.
- E. Cable will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

- A. Install wiring in metal pathways and wireways.
 - 1. Minimum conduit size shall be 3/4 inch. Control and data-transmission wiring shall not share conduits with other building wiring systems.
 - 2. Comply with requirements in Section 280528 "Pathways for Electronic Safety and Security."
 - 3. Comply with requirements in Section 260536 "Cable Trays for Electrical Systems."
 - 4. Comply with requirements in Section 270536 "Cable Trays for Communications Systems."

- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring on Racks and within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM's "Cabling Termination Practices" chapter. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.
 - 2. Install lacing bars and distribution spools.
 - 3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
 - 4. Install conductors parallel with or at right angles to sides and back of enclosure.
 - 5. Connect conductors associated with intrusion system that are terminated, spliced, or interrupted in any enclosure onto terminal blocks.
 - 6. Mark each terminal according to system's wiring diagrams.
 - 7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1 and NFPA 70.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
- D. Install UTP, optical-fiber, and coaxial cables and connecting materials after spaces are complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- E. General Requirements for Cabling:
 - 1. Comply with TIA-568-D.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels. Leave a minimum of 6 inches of slack at outlet terminations and coil loosely into box after termination on outlet fitting.
 - 4. 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.
 - 5. Maintain minimum cable bending radius during installation and termination of cables.
 - 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. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions. Do not exceed manufacturer's rated cable-pulling tension.
 - 9. Riser Cable: Riser cable support intervals shall be in accordance with manufacturer's recommendations.

10. Comply with Section 280544 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart. Cable supports shall be fastened to structural members or floor slabs in accordance with Section 260529 "Hangers and Supports for Electrical Systems."
3. Cable shall not be run in contact with pipes, ducts, or other potentially damaging items. Cables shall not be run through structural members or use structural members, pipes, ducts, or equipment as a support.

G. 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. Cable 72 inches long shall be neatly coiled not less than in diameter below each feed point.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-E recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communication cables or cables in nonmetallic pathways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communication cables in grounded metallic pathways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between cables in grounded metallic pathways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or hp and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 POWER AND CONTROL-CIRCUIT CONDUCTORS

- A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
- B. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits, No. 14 AWG.
 - 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
 - 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.5 CONNECTIONS

- A. Comply with requirements in Section 281300 "Access Control" for connecting, terminating, and identifying wires and cables.
- B. Comply with requirements in Section 282300 "Video Surveillance" for connecting, terminating, and identifying wires and cables.

3.6 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-E, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7 GROUNDING

- A. For communication wiring, comply with TIA-607-B and with BICSI TDMM's "Grounding, Bonding, and Electrical Protection" chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Section 280526 "Grounding and Bonding for Electronic Safety and Security."

3.8 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-D. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 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. Visually inspect UTP and optical-fiber 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-568-D.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 comply with or exceed applicable requirements in TIA-568-D.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.
4. Optical-Fiber Cable Tests:
 - a. Test instruments shall comply with or exceed applicable requirements in TIA-568-D.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) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-D, Method B, One Reference Jumper.
 - 2) Attenuation test results for links shall be less than 2.0 db. Attenuation test results shall be less than that calculated according to equation in TIA-568-D.1.
 - c. 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.
 - d. 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.
- C. 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.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 280513

SECTION 280520 - 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 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Wall Mount Door Control Cabinet.
 - 2. NEMA 4 and NEMA 12 rated wall mount and floor mounted hinged cover enclosures
 - 3. Power strips.
 - 4. Grounding.
 - 5. Labeling.
- B. Related Requirements:
 - 1. 280513 – CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY
 - 2. 280526 – GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY
 - 3. 280528 – PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY
 - 4. 280528.29 – HANGERS AND SUPPORTS FOR ELECTRONIC SAFETY AND SECURITY

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. PBB: Primary Bonding Busbar
- E. RCDD: Registered communications distribution designer.
- F. SBB – Secondary Bonding Busbar
- G. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

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 SBB and its mounting detail showing standoff insulators and wall-mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For 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

- 1. Refer to section 280500, "Common Work Results for Electronic Safety and Security."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment 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."
- B. UL listed.
- C. RoHS compliant.
- D. Compliant with requirements of the Payment Card Industry Data Security Standard.

2.2 WALL MOUNT DOOR CONTROL CABINET.

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:

1. Altronix Trove2 Enclosure (Basis of Design)
2. Hoffman nVent A60H36CLP
3. Wiegman
4. Hammond

B. Specifications:

1. Panel Size H x W x D in.: 27.25 x 21.5 x 6.5
2. Panel: Trove2M2 Backplane
3. Body Gauge: 16
4. Data pocket: Large

2.3 WALL MOUNTED NEMA 12 CONTINUOUS HINGE ENCLOSURES

A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:

1. Hoffman
2. Wiegman
3. Hammond

B. Specifications:

1. Seams continuously welded and ground smooth; no holes or knockouts
2. Gasketed door
3. 3-point latch mechanism operated by oil-tight key-lock handle
4. Concealed, easy-to-remove hinges
5. Data pocket is high-impact thermoplastic
6. Panel supports
7. Oil-resistant gasket
8. Collar studs for mounting optional panel
9. Bonding provision on door
10. AN SI 61 gray, polyester powder paint outside

2.4 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

2.5 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 SBB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches of clearance behind SBB. Connect SBB with a minimum No. 4 AWG grounding electrode conductor from SBB to suitable electrical building ground. Connect rack SBB to near SBB or the PBB.
 - 1. Bond the shield of shielded cable to patch panel, and bond patch panel to SBB or PBB.

3.3 IDENTIFICATION

- A. Coordinate system components, wiring, and cabling complying with TIA-606-D. Comply with requirements in Section 260553 "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-D for Class 2 level of administration, including optional identification requirements of this standard.
- D. Labels shall be machine printed. Type shall be 1/8 inch in height.

END OF SECTION 280520

SECTION 280526 - GROUNDING AND BONDING 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.
- B. Division 27 Specifications

1.2 SUMMARY

- A. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.

1.3 DEFINITIONS

- A. Signal Ground: The ground reference point designated by manufacturer of the system that is considered to have zero voltage.
- B. TBB: Telecommunications Bonding Backbone
- C. SBB: Secondary Bonding Busbar
- D. PBB: Primary Bonding Busbar

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and capacities.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.
- B. Shop Drawings: For grounding and bonding equipment, 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. Grounding: Indicate location and interconnectivity of all grounding busbars (PBB and SBB) and their mounting detail showing standoff insulators and wall-mounting brackets.

- C. All equipment including headend and control equipment will be provided UPS power via division 27 and 26.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For 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. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated in the work include, but are not limited to the following:
 - 1. Allied Wire and Cabling
 - 2. Harger Lightning and Grounding
 - 3. Panduit Corp.
 - 4. Chatsworth
 - 5. Or Approved Equal
- 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.
- D. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 6 AWG, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
 - 5. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.2 CONNECTORS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:

1. Allied Wire and Cabling
 2. Harger Lightning and Grounding
 3. Panduit Corp.
 4. Chatsworth
 5. Or Approved Equal
- 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. Busbar Connectors: Cast silicon bronze, solderless exothermic-type mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated into the work include, but are not limited to the following:
1. Allied Wire and Cabling
 2. Harger Lightning and Grounding
 3. Panduit Corp.
 4. Chatsworth
 5. Or Approved Equal
- B. Grounding Busbars: Predrilled rectangular bars of hard-drawn solid copper, **1/4 by 2 inches** in cross section, length as required to allow for the quantity of connections indicated on Drawings plus 25% spare capacity. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-D.
1. Hole patterns on the Busbars shall accommodate two-hole lugs per the recommendation of BICSI and TIA-607-D standards.
 2. Mounting Hardware: Wall-mount standoff brackets, assembly screws and insulators that provide a 2 1/2-inch (63.5mm) 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 600V switchboards, impulse tested at 5000V.
- C. 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-D. 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 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 stainless-steel or copper-plated hardware for attachment to the rack.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
 1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
 2. Bond shields and drain conductors to ground at only one point in each circuit.
- B. Signal Ground:
 1. For each system, establish the signal ground and label that location as such.
 2. Bond the signal ground to the alternating-current (ac) power system service by connecting to one of the following listed locations, using insulated No. 6 AWG, stranded, Type THHN wire:
 - a. Grounding bar in an electrical power panelboard if located in the same room or space as the signal ground.
 - b. Telecommunications primary bonding busbar (PBB).
- C. Comply with NECA 1.

3.2 APPLICATION

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

3.3 CONNECTIONS

- A. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

- B. 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.
- C. Shielded Cable: Bond the shield of shielded cable to the signal ground. Comply with TIA/EIA-568-D.1 and TIA/EIA-568-D.2 when grounding screened, balanced, twisted-pair cables.
- D. 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.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. 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.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 280526

SECTION 280528.29 - HANGERS AND SUPPORTS FOR ELECTRONIC SAFETY AND SECURITY 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. Conduit and cable support devices.
 - 2. Support for conductors in vertical conduit.
 - 3. Structural steel for fabricated supports and restraints.
 - 4. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - 5. Fabricated metal equipment support assemblies.
- B. Related Requirements:
 - 1. Section 280528 – PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS

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.
 - 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 electronic safety and security hangers and support systems including but not limited to the following:

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 electronic safety and security 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.
- B. Seismic Qualification Certificates: For hangers and supports for electronic safety and security 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.
 - 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.
- C. Surface-Burning Characteristics: Comply with ASTM E 84; 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 D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Conduit and Cable Support Devices: Steel clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- B. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored 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.
- C. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- D. 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.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 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 A 325.
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/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 280528 "Pathways for Electronic Safety and Security 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 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.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch 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.
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten 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 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 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 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.
- B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" 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 A 780.

END OF SECTION 280528.29

SECTION 280528 - PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY 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, tubing, and fittings.
 - 2. Nonmetallic conduits, tubing, and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Nonmetallic wireways and auxiliary gutters.
 - 5. Surface pathways.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
 - 2. Section 270528 "Pathways for Communications Systems" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving communications systems.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. **Surface pathways**
 - 2. Wireways and fittings
 - 3. Boxes, enclosures, and cabinets
 - 4. Underground handholes and boxes
- B. Sustainable Design Submittals:

- C. Shop Drawings: For all pathways, materials, colors. Include plans, elevations, sections, and attachment details.

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.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, and 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 GENERAL

- A. All conduits shall be UL listed and labeled.
- B. Where conduit and other raceway sizes are not specifically shown on the plans, conduits shall be sized in accordance with the requirements of the local building code, BICSI and the NEC. Minimum conduit size shall be $\frac{3}{4}$ " for conduits to doors and card readers, and 1" for cameras and all other devices.
- C. Raceways installed in stud walls or above suspended ceilings shall be Electrical Metallic Tubing. PVC conduit shall not be used.

2.2 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufactures: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work included, but are not limited to the following:
 - 1. Allied Tube & Conduit
 - 2. Republic Conduit

3. Thomas & Betts
 4. Southwire Company
 5. Western Tube and Conduit Corporation
- B. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-E.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch, minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. FMC: Comply with UL 1; zinc-coated steel.
- I. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- J. EMT shall not be utilized for service entrance conductors.
- K. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew where concealed, or compression where exposed.
 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**, with overlapping sleeves protecting threaded joints.
- L. 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.

2.3 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. Manufactures: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work included, but are not limited to the following:
1. Carlon

2. Cantex
 3. JM Eagle
- B. General Requirements for Nonmetallic Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-E.
- C. ENT: Comply with NEMA TC 13 and UL 1653.
- D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- E. LFNC: Comply with UL 1660.
- F. Rigid HDPE: Comply with UL 651A.
- G. Continuous HDPE: Comply with UL 651B.
- H. RTRC: Comply with UL 1684A and NEMA TC 14.
- I. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- J. Fittings for LFNC: Comply with UL 514B.
- K. Solvents and Adhesives: As recommended by conduit manufacturer.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufactures: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work included, but are not limited to the following:
1. Panduit
 2. Hammond Manufacturing
 3. Hoffman
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 4 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.
 2. Comply with TIA-569-E.
- C. Fittings and Accessories: Include 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.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Manufactures: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work included, but are not limited to the following:
 - 1. Panduit
 - 2. Ortronics
 - 3. Wiremold
- B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-E.
- C. 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.
- D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- 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.

2.6 SURFACE PATHWAYS

- A. General Requirements for Surface Pathways:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-E.
- B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Panduit
 - 2. Ortronics
 - 3. Wiremold
- C. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.
 - 1. Panduit
 - 2. Ortronics
 - 3. Wiremold

2.7 BOXES, ENCLOSURES, AND CABINETS

- A. Manufactures: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work included, but are not limited to the following:
 - 1. Raco Hubbell
 - 2. Crouse Hinds
 - 3. Wiremold
 - 4. Hoffman
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-E.
 - 2. 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. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- F. Metal Floor Boxes:
 - 1. Material: Cast 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.
- G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.
 - 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.
- 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, galvanized, cast iron with gasketed cover.
- J. Device Box Dimensions: 4-inches square by 2-1/8 inches deep or 4 inches by 2-1/8 inches by 2-1/8 inches deep.
- K. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4 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: Fiberglass.
- 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- M. Cabinets:
 - 1. NEMA 250, Type 12, 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.

2.8 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 GENERAL

- A. Raceways shall be mechanically and electrically connected to all boxes and fitting and shall be properly grounded.
- B. All pathways shall be installed in such a fashion that the installation meets or exceeds all local seismic requirements.
- C. The routing and location of all conduits and other raceways shall be coordinated with other trades and with the building construction to avoid conflicts.
- D. Where raceways pass through walls, partitions and floors, seal penetrations to provide a neat installation which will maintain the integrity of the waterproofing or fireproofing, as applicable of the structure. Coordinate installation requirements with roofing manufacturer where conduits pass through the roof.
- E. All raceways entering a building from underground shall be sealed to prevent water, moisture, gas, or any other foreign matter from entering the building. Service conduits shall be sealed in accordance with NEC 230-8.

- F. All pathways shall be tested, post installation, to verify the pathway integrity and confirm that the pathway is suitable for the installation of communications cabling.

3.2 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: Type EPC-40-PVC direct buried concrete encased.
 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 4.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT identified for such use.
 3. Exposed and Subject to Severe Physical Damage: GRC. 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
 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. Pathways for Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway, Plenum-type, communications-cable pathway.
 8. Pathways for Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway Riser-type, communications-cable pathway.
 9. Pathways for Concealed General Purpose Distribution of Communications Cable: General-use, General-use, communications-cable pathway Plenum-type, communications-cable pathway.
 10. 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 Pathway Size: 3/4-inch trade size.
- 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 setscrew for concealed locations and compression where conduit is exposed. Comply with NEMA FB 2.10.

- 4. 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 pathways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.3 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-E for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications wiring conduits for which only two 90-degree bends are allowed. Support within 12 inches of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Pathways 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 pathways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways 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 ENT to GRC before rising above floor.
- J. 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.

- K. 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.
- L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- M. 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.
- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to conduit assembly to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- Q. Install pull wires in empty pathways. 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 pathways designated as spare above grade alongside pathways in use.
- R. Surface Pathways:
 - 1. Install surface pathway for surface electrical outlet boxes only where indicated on Drawings.
 - 2. Install surface pathway with a minimum 2-inch radius control at bend points.
 - 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches 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.
- S. 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.
- T. 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.
- U. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- V. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install

- in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
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 temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F 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 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 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.
- W. Flexible Conduit Connections: Comply with NEMA RV 3. Use maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- X. 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.
- Y. 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.
- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- AA. 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.
- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- CC. Set metal floor boxes level and flush with finished floor surface.
- DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 280544 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

3.5 FIRESTOPPING

- A. Compliance: Comply with manufacturer's product data, including product technical bulletins, product catalog installation instruction, and product carton instruction for installation.
- B. Site Verification of Conditions: Verify substrate conditions are acceptable for product installation in accordance with manufacturer's installation.
- C. Install firestopping at penetrations of fire-rated floor and wall assemblies. Install fire stopping to comply with performance requirements listed herein and Section 078413 "Penetration Firestopping".
- D. Install fire stopping to comply with listed fire rated assemblies in accordance with ASTM and UL requirements.
- E. Installer shall be trained and approved by the manufacturer. Protection: Protect installed products from damage during construction operations until final completion.
- F. Inspection: Code official or building inspectors to review proper installation using manufacturer's guidelines.

3.6 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 280528

SECTION 280544 - SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY AND SECURITY 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.
 - 2. 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. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, 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 D 1785, 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 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 pathway or cable.
 - 1. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated in the work include, but are not limited to the following:
 - a. Hilti Speed Sleeves
 - b. Advance Products & Systems, Inc.
 - c. CALIPICO, Inc.
 - d. Metraflex Company (The)
 - e. Pipeline Seal and Insulator, Inc.
 - f. 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: Stainless steel.
 - 4. Connecting Bolts and Nuts: 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. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated in the work include, but are not limited to the following:
 - a. Hilti
 - b. HOLDRITE
 - c. Pipeline Seal and Insulator, Inc.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, 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.

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.
- 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 annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed 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 pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel 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 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 280544

281300 - ACCESS CONTROL 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. Section Includes:
 - 1. Security access control station.
 - 2. One or more security access networked workstations.
 - 3. Security access operating system and application software.
 - 4. Security access controllers connected to high-speed electronic-data transmission network.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.
- C. Product Schedules.
- D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

- B. UPS; Sizing calculations.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Microsoft Windows software documentation.
 - 2. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
 - 3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
 - 4. System installation and setup guides with data forms to plan and record options and setup decisions.

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. Laser Printers: Three toner cassettes and one replacement drum unit.
 - 2. Credential card blanks, ready for printing. Include 1000 blank credentials.
 - 3. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 - 1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one 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 NFPA 70, "National Electrical Code."
- E. Comply with SIA DC-01, SIA DC-03 and SIA DC-07.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Central Station, Workstations, and Controllers:

1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.9 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
 2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
 3. Indoor, Uncontrolled Environment: NEMA 250, Type 4 Type 12 enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
 4. Outdoor Environment: NEMA 250, NEMA 250, Type 4X enclosures. 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 dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
 5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
 6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated in the work include, but are not limited to the following:
1. Amag/Symmetry
 2. Genetec
 3. Others as Approved by the A&E

2.2 DESCRIPTION

- A. Security Access System: PC-based central station, one or more networked PC-based workstations, and field-installed controllers, connected by a high-speed electronic-data transmission network.
- B. System Software: Based on 64 bit, central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:
 - 1. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
 - 2. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of Microsoft Windows.
 - 3. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
 - 4. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with Microsoft Windows.
 - 5. Password-protected operator login and access.
 - 6. Open-database-connectivity compliant.
- C. Network connecting the central station and workstations shall be a LAN using Microsoft Windows-based TCP/IP with a capacity of connecting up to 99 workstations. System shall be portable across multiple communication platforms without changing system software.
- D. Network(s) connecting PCs and controllers shall consist of one or more of the following:
 - 1. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet, star topology network based on TCP/IP.
 - 2. Direct-connected, RS-232 cable from the COM port of the central station to the first controller, then RS-485 cable to interconnect the remaining controllers at that Location.

2.3 OPERATION

- A. Security access system shall use a single database for access-control and credential-creation functions.
- B. Distributed Processing: A fully distributed processing system.
 - 1. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
 - 2. Intermediate controllers for access control are prohibited.
 - 3. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.
- C. Number of Locations:
 - 1. Support at least 32,000 separate Locations using a single PC with combinations of direct-connect, dial-up, or TCP/IP LAN connections to each Location.
 - 2. Locations may be combined to share a common database.
- D. Data Capacity:

1. 130 different card-reader formats.
 2. 999 comments.
 3. 48 graphic file types for importing maps.
- E. Location Capacity:
1. 128 reader-controlled doors.
 2. 50,000 total-access credentials.
 3. 2048 supervised alarm inputs.
 4. 2048 programmable outputs.
 5. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.
- F. System Network Requirements:
1. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
 2. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
 3. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
 4. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.
- G. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.
- H. Field equipment shall include controllers, sensors, and controls.
1. Controllers shall serve as an interface between the central station and sensors and controls.
 2. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.
 3. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
 4. Controllers are classified as alarm-annunciation or entry-control type.
- I. System Response to Alarms:
1. Field device network shall provide a system end-to-end response time of one half second or less for every device connected to the system.
 2. Alarms shall be annunciated at the central station within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the central station.
 3. Alarm and status changes shall be displayed within 100 ms after receipt of data by the central station.
 4. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within five seconds of alarm receipt at the security console.
 5. This response time shall be maintained during system heavy load.

- J. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.
- K. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
- L. Door Hardware Interface:
 - 1. Comply with requirements in Section 087100 "Door Hardware" and Section 087111 "Door Hardware (Descriptive Specification)" for door hardware required to be monitored or controlled by the security access system.
 - 2. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

2.4 APPLICATION SOFTWARE

- A. System Software: Based on 64-bit, Microsoft Windows central-station and workstation operating system and application software.
 - 1. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
 - 2. Graphical user interface shall show pull-down menus and a menu-tree format.
 - 3. Capability for future additions within the indicated system size limits.
 - 4. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
 - 5. Password-protected operator login and access.
- B. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.
- C. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, operate displays, report alarms, generate reports, and help train system operators.
 - 1. Reside at the central station, workstations, and controllers as required to perform specified functions.
 - 2. Operate and manage peripheral devices.
 - 3. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
 - 4. Import custom icons into graphics to represent alarms and I/O devices.
 - 5. Globally link I/O so that any I/O can link to any other I/O within the same Location without requiring interaction with the host PC. This operation shall be at the controller.
 - 6. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host PC. This operation shall be at the controller.
 - 7. Messages from PC to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
 - 8. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other PC-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.

9. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control PC and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
10. Operator audit trail for recording and reporting all changes made to database and system software.
11. Support network protocol and topology, TCP/IP, and LAN/WAN.

D. Workstation Software:

1. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
2. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.

E. Controller Software:

1. Controllers shall operate as autonomous, intelligent processing units.
 - a. Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
 - b. Controllers shall be part of a fully distributed processing-control network.
 - c. The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.
2. The following functions shall be fully implemented and operational within each controller:
 - a. Monitoring inputs.
 - b. Controlling outputs.
 - c. Automatically reporting alarms to the central station.
 - d. Reporting of sensor and output status to the central station on request.
 - e. Maintaining real time, automatically updated by the central station at least once a day.
 - f. Communicating with the central station.
 - g. Executing controller resident programs.
 - h. Diagnosing.
 - i. Downloading and uploading data to and from the central station.
3. Controller Operations at a Location:
 - a. Unlimited number of controllers connected via the security LAN. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti-passback shall remain fully functional within the same Location even when the central station or workstations are off-line.
 - b. In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
 - c. Buffered events shall be handled in a first-in-first-out mode of operation.

4. Individual Controller Operation:

- a. Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.
- b. Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.
- c. Controllers shall provide a response to card readers or keypad entries in less than 0.25 seconds, regardless of system size.
- d. Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.
- e. Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.
- f. On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.
- g. After power is restored, following a power failure, startup software shall initiate self-test diagnostic routines, after which controllers shall resume normal operation.
- h. After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until repaired. If database and application programs are resident, controllers shall immediately resume operation. If not, software shall be restored automatically from the central station.

5. Communications Monitoring:

- a. System shall monitor and report status of LAN health

6. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.

F. PC-to-Controller Communications:

1. Central-station or workstation communications shall use the following:

- a. Direct connection using serial ports of the PC.
- b. TCP/IP LAN interface cards.

2. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.

3. Use multiport communications board if more than two serial ports are needed.

- a. Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
 - b. Connect the first board to an internal PCI bus adapter card.
 4. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.
 5. TCP/IP network interface card (NIV) shall have an option to set the poll-frequency and message-response time-out settings.
 6. PC-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered, and retransmitted if not acknowledged.
- G. Direct Serial or TCP/IP PC-to-Controller Communications:
1. Communication software on the PC shall supervise the PC-to-controller communications link.
 2. Loss of communications to any controller shall result in an alarm at all PCs running the communication software.
 3. When communications are restored, all buffered events shall automatically upload to the PC, and any database changes shall be automatically sent to the controller.
- H. Database Downloads:
1. All data transmissions from PCs to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
 2. If a controller is reset for any reason, it shall automatically request and receive a database download from the PC. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.
- I. Operator Interface:
1. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
 2. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
 3. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
 4. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
 5. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
 6. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:
 - a. Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
 - b. Maps to provide real-time display animation and allow for control of points assigned to them.
 - c. System to allow inputs, outputs, and override groups to be placed on different maps.

- d. Software to allow changing the order or priority in which maps will be displayed.
- 7. Override Groups Containing I/Os:
 - a. System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
 - b. Icon shall change automatically to show the live summary status of points in that group.
 - c. Override group icon shall provide a method to manually control or set to time-zone points in the group.
 - d. Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.
- 8. Schedule Overrides of I/Os and Override Groups:
 - a. To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
 - b. Each schedule shall be composed of a minimum of two dates with separate times for each date.
 - c. The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
 - d. The second time and date shall be assigned the state that the point shall return to when the time and date become current.
- 9. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.
- J. Operator Access Control:
 - 1. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
 - 2. A minimum of 32 passwords shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
 - 3. The password shall not be displayed or printed.
 - 4. Each password shall be definable and assignable for the following:
 - a. Selected commands to be usable.
 - b. Access to system software.
 - c. Access to application software.
 - d. Individual zones that are to be accessed.
 - e. Access to database.
- K. Operator Commands:
 - 1. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
 - 2. Command inputs shall be acknowledged and processing shall start in not less than one half second.
 - 3. Tasks that are executed by operator's commands shall include the following:

- a. Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
 - b. Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
 - c. Place Zone in Secure: Used to remotely activate intrusion-alarm circuits emanating from a specific zone.
 - d. System Test: Allows the operator to initiate a system-wide operational test.
 - e. Zone Test: Allows the operator to initiate an operational test for a specific zone.
 - f. Print reports.
 - g. Change Operator: Used for changing operators.
 - h. Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
 - i. Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
 - j. Run system tests.
 - k. Generate and format reports.
 - l. Request help with the system operation.
 - 1) Include in main menus.
 - 2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
 - 3) Provide navigation to specific topic from within the first help window.
 - 4) Help shall be accessible outside the application program.
 - m. Entry-Control Commands:
 - 1) Revise number of times entry control in first four subparagraphs below can be changed to suit Project. Coordinate with options in "Time Zones" and "Access Levels" paragraphs in "System Database" Article.
 - 2) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
 - 3) Arm or disarm each monitored input up to four times a day through time-zone programming.
 - 4) Enable or disable readers or keypads up to two times a day through time-zone programming.
 - 5) Enable or disable cards or codes up to four times a day per entry point through access-level programming.
4. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:
- a. Command entered is incorrect or incomplete.
 - b. Operator is restricted from using that command.
 - c. Command addresses a point that is disabled or out of service.
 - d. Command addresses a point that does not exist.
 - e. Command is outside the system's capacity.

L. Alarms:

1. System Setup:
 - a. In first seven subparagraphs below, for a stand-alone access-control system, reference is to access points. Terms such as "zone" and "sensor" are used in other related Sections; coordinate with terms used in those Sections if alarms in these systems are integrated into this system.
 - b. Assign manual and automatic responses to incoming-point status change or alarms.
 - c. Automatically respond to input with a link to other inputs, outputs, or operator-response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
 - d. Sixty-character message field for each alarm.
 - e. Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to selectable alarm originating device.
 - f. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
 - g. Allow 25 secondary messages with a field of four lines of 60 characters each.
 - h. Store the most recent 1000 alarms for recall by the operator using the report generator.
 2. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
 3. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
 4. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
 5. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
 6. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a serial interface.
 7. Surveillance Alarm Interface: Allow commands to be sent to surveillance systems during alarms (or input change of state) through serial ports.
 8. Camera Control: Provides operator ability to select and control cameras from graphic maps.
- M. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.
1. Displayed alarm data shall include type of alarm, location of alarm, and secondary alarm messages.
 2. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
 3. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
 4. Alarms initiate a status of "pending" and require the following two handling steps by operators:
 - a. First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."

- b. Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
 5. Each workstation shall display the total pending alarms and total unresolved alarms.
 6. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
 7. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
 8. Alarms shall be displayed and managed from a minimum of four different windows.
 - a. Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
 - b. History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
 - c. Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
 - d. Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
 9. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
 10. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
 11. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
 12. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
 13. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.
 14. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.
- N. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.
 1. Color Code:
 - a. FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
 - b. STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
 - c. YELLOW: Advises operator that a zone is in access.
 - d. MUTED or NO COLOR: Indicates that a zone is secure and that power is on.
 2. Graphics:
 - a. Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
 - b. Allow I/O to be placed on graphic maps by the drag-and-drop method.

- c. Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
 - d. Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.
 - e. Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
 - f. Retain one or both subparagraphs below if Project includes a video surveillance system and this system interfaces with access control. Revise to suit interface conditions.
 - g. Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
 - h. Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.
- O. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.
 - 1. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
 - 2. Printing on Request: An operator may request a printout of any report.
 - 3. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm such as door alarm, intrusion alarm, tamper alarm, etc., the type of sensor, the location, the time, and the action taken.
 - 4. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
 - 5. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
 - 6. Automatic History Reports: Named, saved, and scheduled for automatic generation.
 - 7. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
 - 8. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
 - 9. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
 - 10. Who Is "In" (Muster) Report:
 - a. Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
 - 11. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
 - 12. Activity and Alarm On-Line Printing: Activity printers for use at workstations; prints all events, or alarms only.
 - 13. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.

- a. Initially store history on the hard disk of the host PC.
 - b. Permit viewing of the history on workstations or print history to any system printer.
 - c. The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
 - d. Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.
 - e. Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
 - f. Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.
14. Reports shall have the following four options:
 - a. View on screen.
 - b. Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
 - c. "Save to File" with full path statement.
 - d. System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.
15. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:
 - a. Active, inactive, or future activate or deactivate.
 - b. Code number, name, or imprinted card number.
 - c. Group, Location access levels.
 - d. Start and stop code range.
 - e. Codes that have not been used since a selectable number of days.
 - f. In, out, or either status.
 - g. Codes with trace designation.
16. The reports of system database shall allow options so that every data field may be printed.
17. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.

P. Anti-Passback:

1. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
2. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
3. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.
4. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
5. Provide four separate zones per Location that can operate without requiring interaction with the host PC (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as

"Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.

6. The anti-passback schemes shall be definable for each individual door.
7. The Master Access Level shall override anti-passback.
8. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.

Q. Visitor Assignment:

1. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.
2. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.
3. Allow a visitor designation to be assigned to a credential holder.
4. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
5. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
6. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.

R. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.

1. The enrollment station shall not have alarm response or acknowledgment functions.
2. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
3. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
4. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity-verification subsystems, this shall include biometric data. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
5. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:
 - a. MASK: Determines a specific format with which data must comply.
 - b. REQUIRED: Operator is required to enter data into field before saving.
 - c. UNIQUE: Data entered must be unique.
 - d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
 - e. NAME ID: Data entered will be considered a unique ID for the cardholder.
6. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
7. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.

8. Batch card printing.
 9. Default card data can be programmed to speed data entry for sites where most card data are similar.
 10. Enhanced File Import Utility: Allows the importing of cardholder data and images.
 11. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.
- S. Where appropriate inside the secure perimeter, the access control system shall integrate with the detention monitoring and control system so that the output relays of the access control system are wired to PLC inputs as a request to exit. Depending on the security level of the facility, the request to exit will be processed automatically or, the door may be opened remotely from a control location.

2.5 SYSTEM DATABASE

- A. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.
- B. Database Operations:
1. System data management shall be in a hierarchical menu-tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
 2. Navigational Aids:
 - a. Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
 - b. Point and click feature to facilitate data manipulation.
 - c. Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
 - d. Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.
 3. Data entry shall be automatically checked for duplicate and illegal data and shall be verified for valid format.
 4. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo field is used for noting the purpose for which the item was entered, reasons for changes that were made, and the like.
- C. File Management:
1. File management shall include database backup and restoration system, allowing selection of storage media, including external USB drives, and designated network resources.
 2. Operations shall be both manual and automatic modes. The number of automatic sequential backups before the oldest backup will be overwritten; FIFO mode shall be operator selectable.
 3. Backup program shall provide manual operation from any PC on the LAN and shall operate while system remains operational.
- D. Operator Passwords:

1. Support up to 32,000 individual system operators, each with a unique password.
 2. 4 to 12 alphanumeric characters.
 3. Allow passwords to be case sensitive.
 4. Passwords shall not be displayed when entered.
 5. Passwords shall have unique and customizable password profile, and allow several operators to share a password profile. Include the following features in the password profile:
 - a. Predetermine the highest-level password profile for access to all functions and areas of program.
 - b. Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
 - c. Restrict doors to which an operator can assign access.
 6. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
 7. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.
- E. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).
1. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
 2. Use data-entry windows to view, edit, and issue access levels. Access-authorization entry-management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
 3. Allow assignment of multiple cards/codes to a cardholder.
 4. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
 5. Each door may be assigned four time zones.
 6. Access codes may be up to 11 digits in length.
 7. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
 8. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
 9. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visible annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
 10. Allow each cardholder to be given either an unlimited number of uses or a number from one to 9999 that regulates the number of times the card can be used before it is automatically deactivated.
 11. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.
- F. Security Access Integration:
1. Photo ID badging and photo verification shall use the same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.

2. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
 3. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.
- G. Key control and tracking shall be an integrated function of cardholder data.
1. Provide the ability to store information about which conventional metal keys are issued and to whom, along with key construction information.
 2. Reports shall be designed to list everyone who possesses a specified key.
- H. Facility Codes: System shall accommodate up to 2048 facility codes per Location, with the option of allowing facility codes to work at all doors or only at particular doors.
- I. Operator Comments:
1. With the press of one appropriate button on the toolbar, the user shall be permitted to enter operator comments into the history at any time.
 2. Automatic prompting of operator comment shall occur before the resolution of each alarm.
 3. Operator comments shall be recorded by time, date, and operator number.
 4. Comments shall be sorted and viewed through reports and history.
 5. The operator may enter comments in two ways; either or both may be used:
 - a. Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
 - b. Predefined and stored in database for retrieval on request.
 6. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.
- J. Group:
1. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.
 2. System software shall have the capacity to assign one of 32,000 group names to an access authorization.
 3. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
 4. Allow sorting of history reports and code list printouts by group name.
- K. Time Zones:
1. Each zone consists of a start and stop time for seven days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
 2. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
 3. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
 4. System shall have the capacity for 2048 time zones for each Location.

L. Holidays:

1. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YYYY and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time-zone schedule for that 24-hour period.
2. System shall have the capacity for 32,000 holidays.
3. Three separate holiday schedules may be applied to a time zone.
4. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in the system and will not be purged.
5. Holidays not designated to occur each year shall be automatically purged from the database after the date expires.

M. Access Levels:

1. System shall allow for the creation of up to 32,000 access levels.
2. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
3. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
4. System shall be able to create multiple door and time-zone combinations under the same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same controller.

N. User-Defined Fields:

1. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
2. System shall accommodate a title for each field; field length shall be 20 characters.
3. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
4. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
5. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.
6. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YYYY date format. The credential of the holder will be deactivated on that date.
7. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include a search for a character string.
8. System shall have the ability to print cardholders based on and organized by the user-defined fields.

2.6 SURGE AND TAMPER PROTECTION

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.

1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- B. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

2.7 CENTRAL-STATION AND WORKSTATION HARDWARE

- A. Central-Station Computer: Standard unmodified PC of modular design. The CPU shall be capable of operating all required software without experiencing any slow down of operations.
 1. Memory: 16 GB of usable installed memory, expandable to a minimum of 64 GB without additional chassis or power supplies.
 2. Power Supply: Minimum capacity of 400 W.
 3. Serial Ports: Provide 4 USB 3.0 serial ports one the front and 3 on the rear of the chassis,
 4. 1 SD Card Reader
 5. LAN Adapter Card: 1000BaseT IEEE 802.3 Ethernet adapter.
 6. Color Monitor: Not less than 20 inches, with a minimum resolution of 2560 x 1440 native resolution. The video card shall support at least 16.7 million colors at native resolution
 7. Keyboard: With a minimum of 104 key USB interface
 8. Mouse: Standard, USB interface.
 9. Special-function keyboard attachments or special-function keys to facilitate data input of the following operator tasks:
 - a. Help.
 - b. Alarm Acknowledge.
 - c. Place Zone in Access.
 - d. Place Zone in Secure.
 - e. System Test.
 - f. Print Reports.
 - g. Change Operator.
 10. Disk storage shall include the following, each with appropriate controller:
 - a. Minimum 1 TB internal HDD or SSD.

2.8 CONTROLLERS

- A. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the central station or workstation for controlling its operation.
- B. Subject to compliance with requirements in this article, manufacturers may use multipurpose controllers.
- C. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.

D. Alarm Annunciation Controller:

1. The controller shall automatically restore communication within 10 seconds after an interruption with the field device network provide line supervision of all discrete monitor point circuits.
 - a. Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
 - b. Alarm-Line Supervision:
 - 1) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal and for open, grounded, or shorted conditions using dc change measurements.
 - 2) Transmit alarm-line-supervision alarm to the central station during the next interrogation cycle after the abnormal current condition.
 - c. Outputs: Managed by central-station software.
2. Auxiliary Equipment Power: A GFI service outlet inside the controller enclosure.

E. Entry-Control Controller:

1. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, biometric personnel identity-verification devices, door strikes, magnetic latches, gate and door operators, and exit push buttons.
 - a. Operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the controller and the field-device network.
 - b. Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:
 - 1) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
 - 2) Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control.
 - c. Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
2. Inputs:
 - a. Data from entry-control devices; use this input to change modes between access and secure.
 - b. Database downloads and updates from the central station that include enrollment and privilege information.
3. Outputs:

- a. Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
 - b. Grant or deny entry by sending control signals to portal-control devices include alarm shunt timed to allow entry/exit.
 - c. Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the central station.
 - d. Door Prop Alarm: If a portal is held open for longer than 20 seconds an alarm condition shall be generated.
4. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
5. Data Line Problems: For periods of loss of communication with the central station, or when data transmission is degraded and generating continuous checksum errors, the controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.
 - a. Retain first subparagraph below as needed by security concerns during periods of normal power failure.
 - b. Store transactions during periods of communication loss between the controller and access-control devices for subsequent upload to the central station on restoration of communication.
6. Controller Power: NFPA 70, Class II power-supply transformer, with 12- or 24-V ac secondary, backup battery and charger.
 - a. See the Evaluations in Section 263353 "Static Uninterruptible Power Supply" for information on battery selection.
 - b. Retain one of first two subparagraphs below.
 - c. Backup Battery: rechargeable sealed lead acid; with a full one-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - d. Backup Power-Supply Capacity: 20 minutes of battery supply. Submit battery and charger calculations.
 - e. Power Monitoring: Provide manual, dynamic battery-load test, initiated and monitored at the control center; with automatic disconnection of the controller when battery voltage drops below controller limits. Report by using local controller-mounted digital displays and by communicating status to central station. Indicate normal power on and battery charger on trickle charge. Indicate and report the following:
 - 1) Trouble Alarm: Normal power-off load assumed by battery.
 - 2) Trouble Alarm: Low battery.
 - 3) Alarm: Power off.

2.9 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- A. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
- B. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.

- C. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
 - 1. Indoors, controlled environment.
 - 2. Indoors, uncontrolled environment.
 - 3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
- D. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
- E. Proximity Readers:
 - 1. Active-detection proximity card readers shall provide power to compatible credential cards through magnetic induction and shall receive and decode a unique identification code number transmitted from the credential card.
 - 2. Passive-detection proximity card readers shall use a swept-frequency, RF field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
 - 3. The card reader shall read proximity cards in a range from direct contact to at least 3 inches from the reader.
- F. Narrow Jamb Proximity Readers:
 - 1. Match technology and interface of proximity readers specified above.
 - 2. Narrow, mullion mount reader shall be 6" x 1.7" x 1" and shall be suitable for mounting on a 2" hollow metal door jamb.
- G. Keypads:
 - 1. Entry-control keypads shall use a unique combination of alphanumeric and other symbols as an Identifier.
 - 2. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in random scrambled order.
 - 3. Communication protocol shall be compatible with the local processor.
- H. Keypad Display:
 - 1. Keypads shall include a digital visual indicator and shall provide visible and audible status indications and user prompts.
 - 2. Display shall indicate power on or off and whether user passage requests have been accepted or rejected.
 - 3. Design of the keypad display or keypad enclosure shall limit viewing angles of the keypad as follows:
 - a. Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
 - b. Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
- I. Keypad Response Time:

1. The keypad shall respond to passage requests by generating a signal to the local processor. The response time shall be 800 ms or less from the time the last alphanumeric symbol is entered until a response signal is generated.
- J. Keypad Power:
 1. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.
- K. Keypad Mounting Method:
 1. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
- L. Keypad Duress Codes:
 1. Keypads shall provide a means for users to indicate a duress situation by entering a special code.
- M. Communication Protocol: Compatible with local processor.
- N. Proximity Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
- O. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
- P. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
- Q. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
- R. Card Construction:
 1. Core and laminate or monolithic construction.
 2. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
 3. Incorporate holographic images as a security enhancement.
 4. Furnish equipment for on-site assembly and lamination of credential cards.

2.10 ENROLLMENT CENTER

- A. Equipment for enrolling personnel into, and removing personnel from system database.
- B. Enrollment equipment shall support encoding of credential cards including cryptographic and other internal security checks as required for system.

1. Allow only authorized entry-control enrollment personnel to access the enrollment equipment using passwords.
2. Include enrollment-subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the central station.

C. Entry-Control Enrollment Software:

1. Shall include database management functions for the system, and shall allow an operator to change and modify the data entered in the system as needed.
2. Software shall not have alarm response or acknowledgment functions as a programmable function.
3. Multiple, password-protected access levels shall be provided at the enrollment station.
4. Database management and modification functions shall require a higher operator-access level than personnel enrollment functions.
5. Software shall provide a means for disabling the enrollment station when it is unattended, to prevent unauthorized use.
6. Software shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations to include a credential unit in use at the installation.
7. In the case of personnel identity-verification subsystems, this data shall include biometric data.
8. Software shall allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names shall be customized to suit user and site needs.
9. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.

D. System Capacity: Number of badges shall be limited only by storage space. Badge templates and images shall be in color, supporting the maximum color capability of Microsoft Windows.

E. Badge Configuration:

1. Software for badge template creation shall include a template consisting of background and predetermined locations of photographs, text objects and data fields for text, and bar-code and biometric information. Include automatic sizing of data fields placed on a badge to compensate for names, which may otherwise be too large to fit in the area designated.
2. Allow different badge templates to be used for each department, tenant, or visitor.
3. As a setup option, templates shall be automatically selected for the badge, based on the group to which the credential holder is assigned. Allow the operator to override the automatic template selection and use a template chosen by the operator for creating a badge.
4. Setup shall determine which graphics and credential-holder information will be displayed and where on the card it will be placed. All data in the security access system, such as name, code, group, access level, and any of the 99 user-defined fields, shall be selectable, with the ability to place them anywhere on the card.
5. System shall include an importing, filing, and recall system of stored images and shapes that can be placed on the badge.
6. Allow multiple images on the same badge, including, but not limited to, bar codes, digital photos, and signatures.
7. Support transparent backgrounds so that image is only surrounded by the intended background and not by its immediate background.

F. Photo Imaging: Integral to security access.

1. Import images from bitmap file formats, digital cameras, or scanners. Allow image cropping and editing, WYSIWYG badge-building application, and badge print-preview and printing capabilities.
 2. System shall support multiple images stored for each credential holder, including signatures, portrait views, and profile views.
- G. Text Objects: Badge configuration shall provide for creation of custom text as an object, allowing font selection, typing, scaling, and formatting of the text object. Formatting options shall include changing font, font size, text flow, and text alignment; bending or curving the text object into a circle or semicircle; applying 3-D effects; and applying predefined effects such as tilt, extrusion, or beveling. Text shall be placed and optionally automatically centered within any region of the badge layout.
- H. Badges and Credential Cards:
1. Badges are credential cards that do not contain data to be read by card readers.
 2. Credential cards shall store uniquely coded data used by card readers as an Identifier.
 - a. Proximity Cards or Key Fobs: Use proximity detection without physical contact with the reader for proper operation.
 3. Allow entry-control card to be modified by lamination or direct print process during the enrollment process for use as a picture and identification badge without reduction of readability. The design shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the type of badge holder used at the site.
 - a. Standard card size is the default in first subparagraph below. Coordinate card size with photo-badge system and the card reader.
 - b. Card Size and Dimensional Stability: Standard size, 2-1/8 by 3-3/8 inches; dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
 - c. Card Material: Abrasion resistant, nonflammable, and nontoxic; and impervious to solar radiation and effects of ultraviolet light.
 - d. Insert requirements for security in first subparagraph below if needed. Retain card lamination and assembly equipment if needed at the site.
 - e. Card Construction: Core and laminate or monolithic construction. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
 - 1) Incorporate holographic images as a security enhancement.
 - 2) Furnish equipment for on-site assembly and lamination of credential cards.
- I. Card-Making Equipment: Consisting of a workstation, video camera, video-imaging equipment, and a printer.
1. Camera: 5MP minimum image resolution
 2. Video Imaging: Live-image capture software and hardware and a digital signature capture pad.
 3. Standard workstation, modified as follows:
 4. Printer: Dye-sublimation resin thermal transfer, 300 dpi resolution, 16.7 million colors, accepting cards ranging in size from 2.125 by 3.370 inches to 2.06 by 3.13 inches and having card thickness ranging from 0.009 to 0.040 inch.
 5. Provide 500 cards

2.11 DOOR AND GATE HARDWARE INTERFACE

- A. Exit Device with Alarm: Operation of the exit device shall generate an alarm. Exit device and alarm contacts are specified in Section 087100 "Door Hardware."
- B. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Section 087100 "Door Hardware."
- C. Electric Door Strikes: Signal switches shall transmit data to controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and they shall report a forced entry. Power and signal shall be from the controller. Electric strikes are specified in Section 087100 "Door Hardware."
- D. Electromagnetic Locks: End-of-line resistors shall provide power-line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the controller. Electromagnetic locks are specified in Section 087100 "Door Hardware."
- E. Vehicle Gate Operator: Interface electrical operation of gate with controls in this Section. Vehicle gate operators shall be connected, monitored, and controlled by the security access controllers. Vehicle gate and accessories are specified in Section 323113 "Chain Link Fences and Gates."

2.12 FIELD-PROCESSING SOFTWARE

- A. Operating System:
 - 1. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.
 - 2. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
 - 3. Execution of local processor application programs shall utilize the data in memory resident files.
 - 4. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.
- B. Startup Software:
 - 1. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
 - 2. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
 - 3. Initiates operation of self-test diagnostic routines.
 - 4. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
 - 5. If the database and application programs are resident, the local processor shall immediately resume operation.
- C. Operating Mode:
 - 1. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
 - 2. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.

3. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
 4. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
 5. Local processors shall accept software downloaded from the central station.
 6. Panel shall support on board memory to accomplish firmware downloads from a central location.
- D. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.
- E. Functions:
1. Monitoring of inputs.
 2. Control of outputs.
 3. Reporting of alarms automatically to the central station.
 4. Reporting of sensor and output status to central station upon request.
 5. Maintenance of real time, automatically updated by the central station at least once a day.
 6. Communication with the central station.
 7. Execution of local processor resident programs.
 8. Diagnostics.
 9. Download and upload data to and from the central station.

2.13 FIELD-PROCESSING HARDWARE

- A. Alarm Annunciation Local Processor:
1. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
 2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
 3. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
 4. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
 5. Local processor shall report line supervision alarms to the central station.
 6. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
 7. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
 8. Local processor outputs shall reflect the state of commands issued by the central station.
 9. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
 10. Local processor shall have at least four command outputs.
 11. Local processor shall be able to communicate with the central station via TCP/IP as a minimum.

B. Processor Power Supply:

1. Local processor and sensors shall be powered from an uninterruptible power source.
2. Uninterruptible power source shall provide 20 minutes of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
3. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
4. Batteries shall be sealed, non-outgassing type.
5. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
6. Loss of primary power shall be reported to the central station as an alarm.

C. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.

D. Entry-Control Local Processor:

1. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
3. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, biometric personnel identity-verification devices, door strikes, magnetic latches, gate and door operators, and exit push buttons.
4. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
5. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
6. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
7. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
8. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
9. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
10. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
11. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
12. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
13. Local processor shall report line supervision alarms to the central station.
14. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.

15. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
16. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
17. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
18. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain a date-time- and location-stamped record of each transaction.
19. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
20. Local processor outputs shall reflect the state of commands issued by the central station.
21. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
22. Local processor shall have at least four addressable outputs.
23. The entry-control local processor shall also provide control outputs to portal-control devices.
24. Local processor shall be able to communicate with the central station via TCP/IP as a minimum.

2.14 FLOOR-SELECT ELEVATOR CONTROL

- A. Elevator access control shall be integral to security access.
 1. System shall be capable of providing full elevator security and control through dedicated controllers without relying on the control-station host PC for elevator control decisions.
 2. Access-control system shall enable and disable car calls on each floor and floor-select buttons in each elevator car, restricting passengers' access to the floors where they have been given access.
 3. System setup shall, through programming, automatically and individually secure and unsecure each floor-select button of a car by time and day. Each floor-select button within a car shall be separately controlled so that some floors may be secure while others remain unsecure.
 4. When a floor-select button is secure, it shall require the passenger to use his or her access code and gain access to that floor before the floor-select button will operate. The passenger's credential shall determine which car call and floor-select buttons are to be enabled, restricting access to floors unless authorized by the system's access code database. Floor-select button shall be enabled only in the car where the credential holder is the passenger.
- B. Security access system shall record which call button is pressed, along with credential and time information.
 1. System controller shall record elevator access data.
 2. The controller shall reset all additional call buttons that may have been enabled by the user's credential.
 3. The floor-select elevator control shall allow for manual override from a workstation PC either by individual floor or by cab.

2.15 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

2.16 DURESS ALARM PUSHBUTTON, UNDER COUNTER

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated in the work include, but are not limited to the following:
 - 1. Ademco 269
 - 2. Approved Equal
- B. Specifications
 - 1. Momentary DPDT contacts
 - 2. Switch Rating: 3 Amps at 28VDC

2.17 DURESS ALARM PUSHBUTTON, WALL MOUNT

- A. Manufacturers: Subject to compliance with the requirements, available manufacturer offering products that may be incorporated in the work include, but are not limited to the following:
 - 1. Bulletin 800 Series/ Allen Bradley with Mushroom Head. Button head engraved "DURESS".
 - 2. Approved Equal
- B. Specifications:
 - 1. Silent, single-push switch, for sending an immediate signal to supervisory personnel.
 - 2. The switching mechanism contains a double-pole, double-throw contact supplied with lock mounted switch and two keys.
 - 3. The switch can be reset only with a key by an authorized person.
 - 4. Mounted to single gang aluminum plate.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine rough-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA/EIA 606-C, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
 - 1. Record setup data for control station and workstations.
 - 2. For each Location, record setup of controller features and access requirements.
 - 3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
 - 4. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
 - 5. Assign action message names and compose messages.
 - 6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
 - 7. Prepare and install alarm graphic maps.
 - 8. Develop user-defined fields.
 - 9. Develop screen layout formats.
 - 10. Propose setups for guard tours and key control.
 - 11. Discuss badge layout options; design badges.
 - 12. Complete system diagnostics and operation verification.
 - 13. Prepare a specific plan for system testing, startup, and demonstration.
 - 14. Develop acceptance test concept and, on approval, develop specifics of the test.
 - 15. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."
- B. Install cables and wiring according to requirements in Section 280513 "Conductors and Cables for Electronic Safety and Security."
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Wiring Method: Install wiring in raceway and cable tray 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. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- E. Install LAN cables using techniques, practices, and methods that are consistent with Category rating of components and fiber-optic rating of components, and that ensure Category and fiber-optic performance of completed and linked signal paths, end to end.

- F. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- G. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.4 CABLE APPLICATION

- A. Comply with TIA 569-C, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. Card Readers and Keypads:
 - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
 - 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft., and install No. 20 AWG wire if maximum distance is 500 ft.
 - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
 - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- D. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 ft.
- E. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft.

3.5 GROUNDING

- A. Comply with Section 280526 "Grounding and Bonding for Electronic Safety and Security."
- B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Signal Ground:
 - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
 - 2. Bus: Mount on wall of main equipment room with standoff insulators.

3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.6 INSTALLATION

- A. Push Buttons: Where multiple push buttons are housed within a single switch enclosure, they shall be stacked vertically with each push-button switch labeled with 1/4-inch-high text and symbols as required. Push-button switches shall be connected to the controller associated with the portal to which they are applied, and shall operate the appropriate electric strike, electric bolt, or other facility release device.
- B. Install card readers, keypads and push buttons.

3.7 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 260553 "Identification for Electrical Systems" and with TIA/EIA 606-C.
- B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
 2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
- D. At completion, cable and asset management software shall reflect as-built conditions.

3.8 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.9 FIELD QUALITY CONTROL

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

1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, UTP tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA 568-B.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA 568-B.1.
2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

- C. Devices and circuits will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
 2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.11 PROTECTION

- A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.12 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "Demonstration and Training."
- B. Develop separate training modules for the following:
1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
 2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
 3. Security personnel.
 4. Hardware maintenance personnel.

5. Corporate management.

END OF SECTION 281300

SECTION 282300 - VIDEO SURVEILLANCE 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.
- B. All other Division 28 Specifications

1.2 SUMMARY

- A. Section includes:
 - 1. Video Surveillance Cameras
 - 2. Video Management Display Work Stations
 - 3. Video Management System Software and Programming
 - 4. Integration of the Video Management System with Access Control System and other major subsystems as described herein.
 - 5. Ethernet LAN specifically for the video management system.
- B. Video surveillance system shall be integrated with other systems as specified in: Section 281300 "Access Control System for Electronic Safety and Security".
- C. Provide the following system recording parameters for the video surveillance system:
 - 1. Provide 30 days of storage capacity
 - 2. Provide camera recording of 15 frames per second
 - 3. Provide recording that takes full advantage of the high resolution cameras being used. Do not use compression methods to save storage space that degrade the recorded image and compromise the quality of the recorded image compared to the live view.

1.3 DEFINITIONS

- A. ACS: Access Control System
- B. CPU: Central Processing Unit
- C. GUI: Graphical User Interface
- D. I/O: Input/Output.
- E. LAN: Local Area Network.
- F. PC: Personal computer. Applies to the central station, workstations, and file servers.

- G. PLC: Programmable Logic Controller
- H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- I. UPS: Uninterruptible power supply.
- J. USB: Universal serial bus.
- K. WAN: Wide area network.
- L. WAV: The digital audio format used in Microsoft Windows.
- M. WMP: Windows media player.
- N. Windows: Operating system by Microsoft Corporation.
- O. Workstation: A PC with software that is configured for specific, limited security-system functions.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Video surveillance system 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."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Riser diagrams per building showing network switching, cabling, cameras, power supplies, storage devices, monitors and ancillary equipment.
 - 2. Riser diagrams showing building interconnection requirements to the facility CCTV network.
 - 3. Riser diagram showing interface requirements to ancillary security electronics systems such as PLC, GUI and Intercommunication Systems.
 - 4. Provide floorplan layout showing each camera location and show extents of field of view.
 - 5. Network video storage: Provide complete storage calculations to demonstrate 30 days of RAID-6 storage will be provided for complete system configuration. System shall be configured to record all cameras as follows:
 - a. Motion recording (assume 8 hours/day): 30 frames per second at Native Camera resolution.
 - b. Non-motion recording (assume 16 hours/day): 7.5 frames per second at Native Camera resolution.

6. Indicate electrical characteristics and connection requirements, including layout of completed assemblies, interconnecting cabling, dimensions, weights, and external power requirements.
 7. Rack space requirements for all Video Surveillance equipment. Provide elevation of each rack enclosure.
- C. Product Data: Include an equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation.
1. Materials list and backbox schedule (including any unique backboxes).
 2. Technical Data Sheets on each product, including finishes and dimensions.
 3. Description of system operation.
 4. Storage Calculations: Network video recording equipment will be provided for recording of all cameras. A complete RAID-6 network attached storage array system shall be provided to facilitate a minimum of 30 days retention. The system will be configured to record all cameras as follows:
 - a. Motion recording (assumed 8 hours/day): 30 frames per second at Native Camera resolution.
 - b. Non-Motion recording (assume 16 hours/day): 7.5 frames per second at Native Camera resolution.
 5. Provide Bandwidth Calculations: To ensure that adequate bandwidth is available to support the full functionality of any camera, any recorder and any viewing station.
- D. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, video management workstations, radar detection equipment, and other related components, mounts, to include in emergency, operation, and maintenance manuals.
- E. Record Drawings: During construction, maintain record drawings indicating location of equipment and wiring. Submit a draft of record drawings for the video surveillance management system at the time of Substantial Completion. Submit an electronic version of record drawings for the video surveillance management system at 120 days post Substantial Completion or at the time of Final Close Out, whichever comes first.
- F. Maintenance Service and Support: All video surveillance management system deployments pertaining to service and maintenance shall be undertaken by trained certified employees of the Security Contractor and familiar with the manufacturer's requirements, accepted standards of integration, Owner's requirement and further local regulations.
- G. Any deviation from this specification will require a substitution request.

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. Camera:
 - a. (1) of each camera type used during the project
 2. Network Storage drives:

- a. (2) Spare "hot-swappable" drives
- 3. Network switch ports:
 - a. (5%) spare capacity in each security electronics room

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NECA 1.
- C. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Video Management Servers, Video Management Workstations and monitors, IP surveillance cameras:
 - 1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
 - 2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
 - 3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
 - 4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.9 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Video Surveillance Management System Work Stations, LAN, SAN, servers and peripheral devices: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
 - 2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
 - 3. Indoor, Uncontrolled Environment: NEMA 250, Type 4 Type 12 enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
 - 4. Outdoor Environment: NEMA 250, NEMA 250, Type 4X enclosures. 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 dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
 6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. This section defines the requirements for the video surveillance management system for electronic safety and security.
- B. Electrical services are provided under the electrical portions of this scope of work. Electrical loads, cabling and other requirements for the video surveillance management system equipment and power supplies shall be coordinated with the electrical design.
- C. Communications systems, including backbone fiber and copper, horizontal fiber optic cabling and F/UTP copper, and network equipment are provided under the communications portions of this scope of work. Cabling, cabling types, connectors, ports, and other network connectivity for the video surveillance management system shall be coordinated with the Communications System design.
- D. Furnish and install all security video cameras, mounts, housings, power supplies, network cables, connectors, equipment racks, monitors, and consoles, computer-controlled network switches, workstations, network storage, encoders, decoders, video console displays, and all other hardware and software to provide a fully operational system.
- E. The system shall be installed by a certified dealer/integrator. Certification for installation shall be conducted by the manufacturer and shall provide all necessary knowledge to fulfill the systemization and deployment across diverse networks and infrastructures, as well as provide commissioning abilities at the integrator level.
- F. Perform software programming on site for a functional system, under the supervision of the Owner.
- G. Surge Protection: Surge protection shall be provided in accordance with manufacturer's requirements and in coordination with the electrical design. Protect components from voltage

surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. PoE surge suppression for exterior video devices shall be provided by the Security Contractor.

- H. Coordinate and provide suitable power at proper voltage to support the requirements of all devices provided under this specification.
- I. Security contractor will provide adequate storage for retention of all video cameras for the pre-determined amount of time as follows:
 - 1. Recording Parameters:
 - a. Storage Retention – 30 Days
 - b. Frame Rate - 15 fps
 - c. Motion recording (assume 8 hours/day): 30 frames per second at Native Camera resolution
 - d. Non-motion recording (assume 16 hours/day): 7.5 frames per second at Native Camera resolution.

2.2 2 MP SINGLE IMAGER IP CAMERA

- A. Manufacturers:
 - 1. Axis
 - 2. Hanwha
 - 3. Or Approved Equal
- B. Camera:
 - 1. Image Sensor: RGB CMOS
 - 2. Image Sensor Size: 1 / 2.8
 - 3. Wide Dynamic Range: WDR
 - 4. Min. Illumination/light sensitivity (Color): 0.1 lux
 - 5. Min. Illumination/light sensitivity (B/W): 0.05 lux
 - 6. Max video resolution: 1920x1080
 - 7. Max frames per second: 25/30
 - 8. Focal Length: 9.0 mm (Varifocal, 3.4mm – 8.9mm)
 - 9. Horizontal field of view: 100° - 36°
 - 10. Vertical field of view: 53° - 20°
 - 11. H.264: Baseline, Main, High Profiles
 - 12. H.265: Main Profile
 - 13. Vandal Rating: IK10+
 - 14. POE, IEEE 802.3at, 802.3af

2.3 8 MP MULTI-IMAGER 180° IP CAMERA

- A. Manufacturers:
 - 1. Axis
 - 2. Hanwha

3. Or Approved Equal

B. Camera:

1. Image Sensor: RGB CMOS
2. Image Sensor Size: 1 / 2.8" 2MP x 4
3. Wide Dynamic Range: extreme WDR (120dB)
4. Min. Illumination/light sensitivity (Color): 0.1 Lux (F1.6, 1/30sec)
5. Min. Illumination/light sensitivity (B/W): 0.01 Lux (F1.6, 1/30sec)
6. Max video resolution: 4096x1800 [180° Mode]
7. Max frames per second: 25/30
8. Focal Length: 2.8 mm Fixed Focal x 4
9. Horizontal field of view: 209°
10. Vertical field of view: 83.3°
11. H.264: Baseline, Main, High Profiles
12. H.265: Main Profile
13. Vandal Rating: IK10+
14. POE, IEEE 802.3at, 802.3af

2.4 20 MP MULTI-IMAGER 270° IP CAMERA

A. Manufacturers:

1. Axis
2. Hanwha
3. Or Approved Equal

B. Camera:

1. Image Sensor: RGB CMOS
2. Image Sensor Size: 1 / 1.8" 5MP x 4
3. Wide Dynamic Range: extreme WDR (120dB)
4. Min. Illumination/light sensitivity (Color): 0.11 Lux(F1.92, 30 IRE)
5. Min. Illumination/light sensitivity (B/W): 0 Lux(IR LED on)
6. Max video resolution: 2560x1920
7. Max frames per second: 25/30
8. Focal Length: 4.13~9.4 mm (2.3x) motorized varifocal
9. Horizontal field of view: 87.58°(Wide)~37.34°(Tele)
10. Vertical field of view: 64.58°(Wide)~28.04°(Tele)
11. H.264: Baseline, Main, High Profiles
12. H.265: Main Profile
13. Vandal Rating: IK10+
14. POE, IEEE 802.3at, 802.3af

2.5 20 MP MULTI-IMAGER 360° IP CAMERA

A. Manufacturers:

1. Axis
2. Hanwha
3. Or Approved Equal

B. Camera:

1. Image Sensor: RGB CMOS
2. Image Sensor Size: 1 / 1.8" 5MP x 4
3. Wide Dynamic Range: extreme WDR (120dB)
4. Min. Illumination/light sensitivity (Color): 0.11 Lux(F1.92, 30 IRE)
5. Min. Illumination/light sensitivity (B/W): 0 Lux(IR LED on)
6. Max video resolution: 2560x1920
7. Max frames per second: 25/30
8. Focal Length: 4.13~9.4 mm (2.3x) motorized varifocal
9. Horizontal field of view: 87.58°(Wide)~37.34°(Tele)
10. Vertical field of view: 64.58°(Wide)~28.04°(Tele)
11. H.264: Baseline, Main, High Profiles
12. H.265: Main Profile
13. Vandal Rating: IK10+
14. POE, IEEE 802.3at, 802.3af

2.6 20 MP MULTI-IMAGER 360° IP CAMERA + 2 MP PAN/TILT/ZOOM

A. Manufacturers:

1. Axis
2. Hanwha
3. Or Approved Equal

B. Camera:

1. Image Sensor: RGB CMOS
2. Image Sensor Size: 1 / 1.8" 5MP x 4 + 2MP 32x PTZ
3. Wide Dynamic Range: [2MP] 150dB, [5MP] 120dB
4. Min. Illumination/light sensitivity (Color): 0.11 Lux(F1.92, 30 IRE)
5. Min. Illumination/light sensitivity (B/W): 0 Lux(IR LED on)
6. Max video resolution: 2560x1920 x 4 [5MP], 1920 x 1080 [2MP]
7. Max frames per second: [2MP] 60fps, [5MP] 30fps
8. Focal Length: 4.44~142.6mm (32x) zoom
9. Horizontal field of view: 61.8°(Wide)~2.19°(Tele)
10. Vertical field of view: 36.2°(Wide)~1.24°(Tele)
11. H.264: Baseline, Main, High Profiles
12. H.265: Main Profile
13. Vandal Rating: IK10+
14. POE, IEEE 802.3at, 802.3af

2.7 12 MP SINGLE-IMAGER 360° IP CAMERA

A. Manufacturers:

1. Axis
2. Hanwha
3. Or Approved Equal

B. Camera:

1. Image Sensor: RGB CMOS
2. Image Sensor Size: 1 / 2.3"
3. Wide Dynamic Range: extreme WDR (120dB)
4. Min. Illumination/light sensitivity (Color): 0.39 Lux (F2.2, 1/30sec)
5. Min. Illumination/light sensitivity (B/W): 0 Lux(IR LED on)
6. Max video resolution: (1:1): 3008x3008~480x480, Double panorama(2:1): 3584x1792~640x320, Single panorama(4:1): 3584x896~640x160, Quad view: 3584x2688~640x480, Q1/Q2/Q3/Q4(4:3): 1792x1344~640x480
7. Max frames per second: H.265/H.264: Original view-
Max.30fps/25fps@3008x3008(60Hz/50Hz), Double panorama-
Max.30fps/25fps@3584x1792(60Hz/50Hz) Single panorama-
Max.30fps/25fps@3584x896(60Hz/50Hz)
8. Focal Length: 1.08mm fixed focal
9. Horizontal field of view: 187°
10. Vertical field of view: 187°
11. H.264: Baseline, Main, High Profiles
12. H.265: Main Profile
13. Vandal Rating: IK10+
14. POE, IEEE 802.3at, 802.3af

2.8 27" DESKTOP DISPLAY

A. Manufacturers:

1. Bosch
2. Samsung
3. Approved Equal

B. Display:

1. Contrast Ratio: 1000
2. Display Color: Color
3. Display Resolution: 3840 x 2160 px
4. Display Size: 27 in

C. System operation:

1. Provide complete system for viewing of remote scene including control of equipment accessories.
2. Monitor functional requirements – Security Control Workstations:
 - a. Monitor #1: Primary Intercom call-up / Control Station call-up.
 - b. Monitor #2+: Each monitor – quad view with sequencing of all new facility cameras based on area (area camera selections per monitor shall be coordinated with the User).
3. Provide automatic call-up of scene to selected monitors on operation of intercom icon associated with camera viewing intercom scene. At movement doors with cameras on both sides of door, the camera on each side of door shall be called up to associated monitors adjacent to touchscreen.

2.9 VIDEO MANAGEMENT SYSTEM SERVER AND RECORDERS (ARCHIVING)

A. Manufacturers:

1. Dell
2. HP
3. Or approved equal

B. Server:

1. Intel® Xeon® Silver or better.
2. Windows Server, Essentials Ed, Factory Install, No MED, 2SKT, 1VM Storage:
3. 16GB UDIMM, 2133MT/s, ECC
4. 1TB Minimum Solid-State Drive
5. RAID 6 storage capable of storing the required amount of footage as described in the contract documents.

C. General:

1. Provide a server/storage solution that is certified by the Video Management System (VMS) manufacturer, comes pre-loaded with the specified software, video roles and includes a performance guarantee.
2. Provide a solution to record every camera at the resolution of the camera as specified in the "System Requirements" within this specification section. Provide a RAID 6 storage array of sufficient size to accommodate the recording requirements. Provide a pricing option to the owner to extend the recording to 60 days.
3. Provide a storage solution that is configured with adequate input/output operations and read/write speeds to ensure there is no negative impact on system performance during normal operation, drive failure or drive rebuild/recovery.
4. Provide drive monitoring with remote alarming at Central Control for indicating a drive failure anywhere in the system.

2.10 VIDEO MANAGEMENT SYSTEM SOFTWARE

A. Manufacturers:

1. Hanwha Wave Miller Electric?
2. AE Approved Equal

B. Video Management System (VMS) General Requirements:

1. The VMS shall be based on a true open architecture that allows the use of nonproprietary workstation and server hardware, non-proprietary network infrastructure and non-proprietary storage.
2. The VMS shall offer a complete and scalable video surveillance solution that allows cameras to be added on a unit-by-unit basis.
3. The VMS shall interface with IP cameras, video encoders and video decoders, hereafter referred to as digital video servers (DVS). The VMS shall support DVS from various manufacturers.
4. The VMS shall integrate DVS using the DVS native SDK and ONVIF industry standards to interface to the DVS:

5. All video streams supplied from analog cameras or IP cameras shall be digitally encoded in H.265, H.264, MPEG-4, MPEG-2, MJPEG, MxPEG, Wavelet or JPEG2000 compression formats and recorded simultaneously in real time.
6. All audio streams supplied from IP video servers shall be digitally encoded in g711 (ulaw), g721, g723, or AAC compression formats and recorded simultaneously in real time.
7. Each camera's bit rate, frame rate, and resolution shall be set independently from other cameras in the system and altering these settings shall not affect the recording and display settings of other cameras.
8. The VMS shall be able to use multiple CCTV keyboards to operate the entire set of cameras throughout the system, including brands of cameras from various manufacturers and including their PTZ functionalities.
9. The VMS shall be able to retrieve and set the current position of PTZ cameras using XYZ coordinates.
10. The VMS shall support PTZ camera protocols from multiple manufacturers and IP protocols.
11. The VMS shall arbitrate the user conflict on PTZ usage based on user levels per camera.
12. The VMS shall support joystick and control keyboards.
13. The VMS shall allow for the configuration of a time zone for each camera connected to a DVS. For playback review, users shall have the ability to search for video based on a synchronized time system.
14. Audio and Video storage configuration shall either be:
 - a. Internal or external IDE/SATA/SAS.
 - b. Internal or external SCSI/iSCSI/Fiber Channel.
 - c. Within the overall storage system, it shall be possible to include disks located on:
 - 1) External PCs on a LAN or WAN
 - 2) Network Attached Servers (NAS) on a LAN or WAN
 - 3) Storage Area Networks (SAN)
15. The VMS shall not limit the actual storage capacity configured per server.

C. Cyber Security Requirements:

1. The VMS shall be an IP enabled solution. All communication between the VMS shall be based on standard TCP/IP protocol and shall use TLS encryption with digital certificates to secure the communication channel.
2. The VMS shall support user authentication with claims-based authentication using external providers. External providers shall include:
 - a. ADFS (Active Directory Federation Services)
3. The VMS shall limit the IP ports in use and shall provide the Administrator with the ability to configure these ports.
4. The VMS shall support only secured media stream requests, unless explicitly configured otherwise. Secured media stream requests shall be secured with strong certificate-based authentication leveraging RTSPS (RTSP over TLS). Client authentication for media stream requests is claims-based and may use a limited lifetime security token.
5. The VMS shall offer the ability to encrypt the media stream, including video, audio, and metadata with authenticated encryption. Media stream encryption shall be done at rest and in transit and be a certificate-based AES 128-bits encryption. The VMS shall:

- a. Allow encryption to be set on a per camera basis for all or some of the cameras.
 - b. Provide certificates for different groups of CSA or users who have been granted access to decrypted streams.
 - c. Not decrease the recording performance by more than 50% when encryption is enabled.
 - d. Use Secure RTP (SRTP) to encrypt the payload of a media stream in transit and allow multicast and unicast of the encrypted stream.
 - e. Use a random encryption key and change periodically.
 - f. Allow encrypted streams to be exported.
 6. The VMS shall support end to end encrypted streams with cameras supporting Secure RTP (SRTP) both in unicast and multicast from the camera.
- D. Failover and Standby Requirements:
1. The VMS shall support native and off-the-shelf failover options.
 2. Failover Directory
 - a. A Standby Directory shall be included which acts as a replacement on hot standby, ready to take over as the acting Directory in case the primary Directory fails. The failover shall occur in less than 1 minute. No action from the user shall be required.
 - b. The VMS shall support up to five (5) Directories on standby, lined up to take over as the acting Directory in a cascading fashion.
 - c. The Standby Directory shall keep its configuration database synchronized with the primary Directory.
 - d. The Standby Directory shall support disaster recovery scenarios where a server can be located in another geographic area (or building) and only take over if all other Directories become offline.
 - e. The Standby Directory shall support synchronization of the configuration databases using a backup and restore mechanism. The synchronization period shall be configurable.
 - f. The Standby Directory shall support real-time synchronization of the configuration databases using SQL Mirroring or SQL Always On.
 3. Off-the-shelf standby/failover options (excluding the VMS Archiver) shall include:
 - a. Windows Clustering.
 - b. NEC Express Cluster X LAN.
- E. Archiving:
1. The Archiver (role) shall use an event and timestamp database for the advanced search of audio/video archives. This database shall use Microsoft SQL.
 2. The Archiver shall protect archived audio/video files and the system database against network access and non-administrative user access.
 3. The Archiver shall digitally sign recorded video using 248-bit RSA public/private key cryptography.
 4. The Archiver shall offer a plug and play type hardware discovery service with the following functionalities:
 - a. Automatically discover DVS units as they are attached to the network.
 - b. Discover DVS units on different network segments, including the Internet, and across routers with or without network address translation (NAT) capabilities.

5. The Archiver shall configure the key frame interval (I-frame) in seconds or number of frames.
6. The Archiver shall provide a pre-alarm and post-alarm recording option that can be set between one second and 5 minutes on a per camera basis.
7. The Archiver shall provide the functionality of storing of video and audio streams based on triggering events, such as:
 - a. Digital motion detection.
 - b. Digital input activation.
 - c. Macros.
 - d. Through SDK application recording.
8. The Archiver shall perform video motion detection on each individual camera based on a grid of motion detection blocks. All of the video motion detection settings are to be configurable on schedule. A global sensitivity threshold is to be provided which will reduce motion detection sensitivity when the video signal is noisy or when a lot of false hits are incurred.
9. The Archiver shall support the DVS with edge recording capabilities and include the following:
 - a. The ability to playback the video recorded on the DVS at different speeds.
 - b. The ability to offload (video trickling) the video recorded on the DVS on schedule, on event, or manually to store it on the Archiver.
 - c. It shall be possible to filter the video that is being offloaded using one on multiple of the following filters:
 - 1) Time interval
 - 2) Playback request
 - 3) Video analytic events
 - 4) Motion events
 - 5) Bookmarks
 - 6) Alarms
 - 7) Input pin events
 - 8) Unit offline events
 - d. The Archiver shall be provided with proven performance and scalability figures:
 - 1) The Archiver's performance shall be guaranteed during the rebuild of a disk from Raid 6 disk groups. The rebuild process shall not affect the recording and playback capabilities.
 - e. The Archiver shall provide the ability to encrypt the media stream coming from the DVS including the video, audio, and metadata.

F. Auxiliary Archiver:

1. An The Auxiliary Archiver shall be used to produce redundant archives (video, events, or bookmarks) for any camera in the system, on a case-by-case basis.
2. The Auxiliary Archiver shall record a camera on a different schedule than the Archiver.
3. The Auxiliary Archiver shall archive any of the standard video streams for archiving. The standard video stream usages are: Live, Recording, Remote, Low Resolution, and High Resolution.

G. Standby Archiver:

1. A Standby Archiver shall be provided which acts as a replacement Archiver on hot standby, ready to take over the functions of the primary Archiver role. The failover shall occur in less than 1 minute. With no action from the user.
2. The Standby Archiver assigned to an Archiver role entity shall automatically provide protection for all DVS connected to that Archiver role.
3. The Standby Archiver shall protect the primary Archiver role against the following failures:
 - a. Server failure (hardware or software).
 - b. Storage failure, such as Archiver Role detects that it cannot read or write to any of its allocated disks.
4. It shall be possible for a single VMS server to act as the standby server of multiple Archiver roles.
 - a. Each Archiver role shall have priority value if multiple Archiver Roles fail at the same time on the same standby server.
5. It shall be possible for any Archiver role in the system to be designated as another's standby and vice-versa.
6. For each Archiver role, set standby Archivars so that if the first failover Archiver fails the failover will automatically occur to a third server.
7. The Standby Archiver shall act as a Redundant Archiver.
8. The Redundant Archiver shall maintain an exact copy of everything recorded by the default Archiver, i.e., audio/video archives, events, and bookmarks.
9. Configure redundancy on a camera-by-camera basis.
10. The Redundant Archiver shall use a multicast video stream from the DVS and shall not require an additional connection to any DVS.

H. General Client Software Requirements:

1. The Client Software Applications (CSA) shall provide the user interface for VMS configuration and monitoring over any network and be accessible locally or from a remote connection.
2. The CSA shall consist of the Configuration UI for system configuration and the Monitoring UI for monitoring. The CSA shall be Windows-based and provide an easy-to use Human Machine Interface (HMI).
3. The CSA for monitoring shall support running in 64-bit mode.
4. The Server Administrator shall be used to configure the server database(s). It shall be web-based and accessible locally or across the network.
5. The CSA shall seamlessly merge video functionalities within the same user application.
6. The VMS shall use the latest user interface (UI) development and programming technologies. such as Microsoft WPF (Windows Presentation Foundation), the XAML markup language, and the .NET software framework.
7. Logging on to a CSA shall be done either through locally stored VMS user accounts and passwords or using the operators Windows credentials with Active Directory integration enabled.
8. When integrated with Microsoft's Active Directory, the CSA and VMS shall authenticate users using their Windows credentials.
9. Configuration UI and Monitoring UI Home Page and Tasks
 - a. The Configuration UI and Monitoring UI shall be task oriented.

- b. Tasks shall be accessible via the Home Page of either the Configuration or the Surveillance CSA.
 - c. Newly created tasks shall be accessible via the Configuration UI or the Monitoring UI taskbar.
 - d. Similar tasks shall be grouped into the following categories:
 - 1) Investigation: Video bookmark/motion/archive reports, activity reports, alarm reports, and more.
 - 2) Maintenance: Configuration reports, troubleshooters, audit trails, health related reports, and more.
 - e. An operator shall be able to launch a specific task only if he or she has the appropriate privileges.
 - f. The Home Page content shall be customizable through the use of privileges to hide tasks that an operator should not have access to and through a list of favorite and recently used tasks. In addition, editing a VMS XML file to add new tasks on the fly shall also be possible.
10. Provide a site license enterprise system with greater than 60 simultaneous client connections for this project.
11. The live video viewing capabilities of the Monitoring UI shall include:
- a. The ability to display all cameras attached to the VMS and all cameras attached to federated systems.
 - b. Support for live video monitoring on each and every display tile within a task in the user's workspace.
 - c. The VMS shall support uninterrupted video streaming. The system shall keep existing video connections active in the event that a connection becomes unavailable.
 - d. The ability to drag and drop a camera into a display tile for live viewing.
 - e. The ability to drag and drop a camera into a display tile for live viewing on an analog monitor connected to an IP hardware decoder (converting an IP encoded stream into an analog video signal).
 - f. The ability to drag and drop a camera from a map into a display tile for live viewing.
 - g. Support for digital zoom on live camera video streams.
 - h. The ability for audio communication with video units with audio input and output.
 - i. The ability to control pan-tilt-zoom, iris, focus, and presets.
 - j. The ability to bookmark important events for later retrieval on any archiving camera and to uniquely name each bookmark in order to facilitate future searches.
 - k. The ability to start/stop recording on any camera in the system that is configured to allow manual recording by clicking on a single button.
 - l. The ability to activate or de-activate viewing of all system events as they occur.
 - m. The ability to switch to instant replay of the video for any archiving camera with the simple click of button.
 - n. The ability to take snapshots of live video and be able to save or print the snapshots.
 - o. The ability to view the same camera multiple times in different tiles.
- I. The video playback (archive playing) capabilities of the Monitoring UI shall include:
- 1. Audio and video playback for any time span.
 - 2. Video playback on each and every display tile.
 - 3. Instantly replay the video for any archiving camera with the simple click of a button.

4. Select between instant synch of all video streams in playback mode, allowing operators to view events from multiple angles or across several camera fields, or non-synchronous playback.
5. The ability to simultaneously view the same camera in multiple tiles at different time intervals.
6. The ability to control playback with:
 - a. Pause.
 - b. Lock Speed.
 - c. Forward and Reverse Playback at: 1x, 2x, 4x, 6x, 8x, 10x, 20x, 40x, 100x.
 - d. Forward and Reverse Playback frame by frame.
 - e. Slow Forward and Reverse Playback at: 1/8x, 1/4x, 1/3x, 1/2x.
 - f. Loop playback between two-time markers.
7. The ability to display a single timeline or one timeline for each selected video stream, which would allow the operator to navigate through the video sequence by simply clicking on any point in the timeline.
8. The ability to display the level of motion at any point on a timeline.
9. The ability to clearly display bookmarked events on the timeline(s).
10. The ability to query archived video using various search criteria, including, but not limited to, time, date, camera, and area.
11. The tool necessary for searching video and associated audio based on user- defined events or motion parameters.
12. The ability to define an area of the video field in which to search for motion as well as define the amount of motion that will trigger search results. The Monitoring UI shall then retrieve all archived video streams that contain motion that meets the search parameters. There shall be a graphical timeline on which the time of each search hit shall be indicated.
13. The ability to browse through a list of all bookmarks created on the system and select any bookmarked event for viewing.
14. The ability to add bookmarks to previously archived video for easier searching and retrieval.
15. Support for digital zoom on playback video streams.
16. Still image export to PNG, JPEG, GIF, and BMP format with Date and Time stamp, and Camera Name on the image (snapshot).
17. Tools for exporting video and a self-contained video player on various media such as USB keys or CD/DVD-ROM. This video player shall be easy to use without training and shall still support reviewing video metadata, such as bookmark, or navigating the video with functions like panoramic camera view dewarping.
18. Tools for exporting video sequences in standard video formats, such as ASF or MP4.
19. The ability to encrypt exported video files.
20. The ability for an operator to load previously exported video files from their computer or network.
21. The ability for queries to be saved upon closing the CSA and reappear when the application is reopened.
22. The ability to dynamically block, on demand, video stream dynamically to lower- level users to prevent access, for a specific time, to live and recorded video.
23. A tool building and exporting a set of videos into a single container. This tool shall allow the operator to build sequences of video to create a storyboard and allow the export of synchronous cameras.
24. The ability to store the video export and still image export at a pre-defined storage location.
25. An interface with the ability to list, search, and manipulate previously generated video exports.
26. The ability to export sequences of video in open standards including ASF and MP4.

J. Server Administrator User Interface Requirements:

1. The Server Administrator shall be used to configure the system and the Directory Role (main configuration) and its database(s), to apply the license, and more.
2. The Server Administrator shall be a web-based application. Through the Server Administrator, it shall be possible to access the system across the network or locally on the server.
3. Access to the Server Administrator shall be protected via login name, password, and encrypted communications.
4. The Server Administrator shall allow the administrator (user) to perform the following functions:
 - a. Manage the system license.
 - b. Configure the database(s) and database server for the Directory Role,
 - c. Activate/Deactivate the Directory Role.
 - d. Manually back up the Directory Role database(s) and/or restore the server database(s), as well as configure scheduled backups of the databases.
 - e. Define the client-to-server communications security settings.
 - f. Configure the network communications hardware, including connection addresses and ports.
 - g. Configure system SMTP settings (mail server and port).
 - h. Configure event and alarm history storage options.

K. Unified Web Client (UWC) General Requirements:

1. The VMS shall support a unified web client (UWC) for access control and video.
2. The UWC shall be a truly thin client with no download required other than an internet web browser or standard web browser plugins.
3. The UWC shall be platform independent and run within Microsoft Edge, Internet Explorer, Firefox, Safari, and Google Chrome.
4. Web pages for the web client shall be managed and pushed by the Web Server Role. Microsoft IIS or any other web hosting service shall not be required given that all the web pages shall be hosted by the Web Server Role.
5. Video Stream shall be redirected to the Web Client with no stream transformation or reencoding for all streams in H264.
6. Provide a site license enterprise system with greater than 60 simultaneous client connections for this project.

L. VMS General Requirements:

1. The VMS shall be an enterprise class IP-enabled security and safety software solution.
2. The VMS shall support the seamless unification of IP video management system (VMS) under a single platform. The VMS user interface (UI) applications shall present a unified security interface for the management, configuration, monitoring, and reporting of embedded VMS systems and associated edge devices.
3. Licensing
 - a. A single central license shall be applied centrally on the configuration server.
 - b. There shall be no requirement to apply a license at every server computer or client workstation.
 - c. Based on selected options, one or more embedded systems shall be enabled or disabled.

M. Hardware and Software Requirements:

1. The VMS and embedded systems (video, license plate recognition, and access control) shall be designed to run on a standard PC-based platform loaded with a Windows operating system. The preferred operating system shall be coordinated with the Owner following the manufacturer supported operating systems.
2. The core client/server software shall be built in its entirety using the Microsoft
3. .NET software framework and the C# (C-Sharp) programming language.
4. The VMS database server(s) shall be built on Microsoft's SQL Server. The preferred SQL version shall be coordinated with the Owner and compatible with the VMS.
5. The VMS shall be compatible with virtual environments, including VMware and Microsoft Hyper-V.
6. The VMS shall use the latest user interface (UI) development and programming technologies such as Microsoft WPF (Windows Presentation Foundation), the XAML markup language, and .NET software framework.

N. VMS Architecture:

1. The VMS shall be based on a client/server model. The VMS shall consist of a standard Server Software Module (SSM) and Client Software Applications (CSA).
2. The VMS shall be an IP enabled solution. All communication between the SSM and CSA shall be based on standard TCP/IP protocol and shall use TLS encryption with digital certificates to secure the communication channel.
3. The SSM shall be a Windows service that can be configured to start when the operating system is booted and run in the background. The SSM shall automatically launch at computer startup, regardless of whether or not a user is logged on the machine.
4. Users shall be able to deploy the SSM on a single server or across several servers for a distributed architecture. The VMS shall not be restricted in the number of SSM deployed.
5. The VMS shall protect against potential database server failure and continue to run through standard off-the-shelf solutions.
6. The VMS shall support up to unrestricted instances of CSA connected at the same time.
7. The VMS shall support an unrestricted number of logs and historical transactions (events and alarms) with the maximum allowed being limited by the amount of drive space available.
8. The VMS shall include uninterrupted video streaming. The CSA shall keep existing video connections active in the event that an SSM (except Archiver) becomes unavailable.

O. Optional Roles:

1. The Federation Role shall be responsible for creating a large virtual system consisting of hundreds or thousands of independent and remote VMS systems.
2. The Global Cardholder Synchronizer Role shall be responsible for synchronizing cardholder and credential data between the local site and a central site. Synchronization between remote sites shall also be included.
3. The Active Directory Role shall be responsible for synchronizing user accounts and cardholder accounts with a Microsoft Active Directory server
4. The Web SDK Role shall be responsible for connecting the VMS to any application or interface developed with the Web Service SDK. Applications developed with the Web Service SDK shall be platform independent and rely on the REST protocol for communications.
5. The Communication Management Role shall be responsible for registering the SIP communication endpoints and for managing the call routing.

6. The Web Server Role shall be responsible for managing incoming Web Client connection and hosting the web pages for the Web Client. The Web Server Role acts as a proxy for the client connections and can be installed in a DMZ for additional security.
7. The Media Gateway Role shall be responsible for connecting any video stream to a third-party system using standard RTSP protocol. This role shall provide access to live video.

P. Server Monitoring Service (Watchdog):

1. The VMS shall include a Server Monitoring Service that continuously monitors the state of the Server Software Module (SSM) service.
2. The Server Monitoring Service shall be a Windows service that automatically launches at system startup, regardless of whether or not a user is logged into his account.
3. The Server Monitoring Service shall be installed on all PCs/servers running an SSM. In the event of a malfunction or failure, the Server Monitoring Service shall restart the failed service. As a last resort, the Server Monitoring Service shall reboot the PC/server should it be unable to restart the service.

Q. VMS Third Party Integration

1. Microsoft Active Directory Integration

- a. The VMS shall include a direct connection to one or multiple Microsoft Active Directory server via the Active Directory Role(s). Active Directory integration shall enable the synchronization of information from the Active Directory server to the VMS.
- b. Active Directory integration shall permit the central management of the VMS users, user groups, cardholders, and cardholder groups.
- c. Active Directory integration shall permit the central management of the VMS users, user groups, cardholders, and cardholder groups.
- d. Active Directory integration shall permit the central management of the VMS users, user groups, cardholders, and cardholder groups.
- e. The VMS shall be able to connect to and synchronize data from multiple Active Directory servers.
- f. The VMS shall support synchronizing Active Directory Universal Groups as well as security groups belonging to other domains within the same forest.
- g. The VMS shall support Microsoft Active Directory encryption using LDAP SSL.
- h. When enabled, Active Directory shall manage user logon to the VMS client applications through the user's Windows credentials. Logging to the VMS shall utilize native Active Directory password management and authentication features.
- i. It shall be possible to synchronize the following VMS entities and their information from Active Directory with the VMS:
 - 1) Users (username, first and last names, email address, and more).
 - 2) User groups (user group name, description, and group email address).
 - 3) Active Directory attributes to VMS custom fields.
- j. When enabled, the addition, removal, or suspension of a user's Windows account in Active Directory shall result in the creation, deletion, or disabling of the equivalent user account in the VMS.
- k. Supported synchronization methods for additions, modification, and deletions of synchronized entities shall include on first logon (users only), manual synchronization, and scheduled synchronization.

- I. The VMS shall support user connections across independent organizations by connecting to an external ADFS (Active Directory Federation Services) service using claims-based authentication.
- R. VMS Software Development Kit (SDK)
 1. VMS SDK shall be included to support custom development for the platform.
 2. The SDK shall include functionalities specific to the embedded (VMS) systems.
 3. Integration with external applications and databases shall be possible with the SDK
 4. The SDK shall enable end-users to develop new functionality (user interface, standalone applications or services) to link the VMS to third party business systems and applications, such as Badging Systems, Human Resources Management Systems (HRMS), and Enterprise Resource Planning (ERP) systems.
 5. The SDK shall be based on the .NET framework.
 6. The SDK shall support dynamic or transactional updates to the VMS configuration. It shall also support change notification of VMS entity configuration.
 7. The SDK shall provide an extensive list of programming functions to view and/or configure core entities such as: users and user groups, alarms, custom events, and schedules, and more.
 8. The SDK shall provide an extensive list of programming functions to view and configure the VMS.
 9. The SDK shall provide an extensive list of programming functions to view and configure most ACS entities such as: cardholders, cardholder groups, visitors, credentials, access rules (modify only), and custom fields.
 10. The SDK shall be able to receive real time events from the following VMS entities: users and user groups, areas, zones, cameras, video units, doors, door controllers (units), cardholders, cardholder groups, and credentials.
 11. The SDK shall be able to query the history of events for areas, cameras, zones, alarms, cardholders, credentials, visitors, doors, query license plate read events, license plate hit events, generate a license plate hits report, generate a license plate reads report.
 12. The SDK shall support the following alarm functions: view alarms in real time, acknowledge alarms, change priority, and change recipient.
 13. The VMS SDK architecture shall include integration with the Door Control HMI/PLC system. (See specification 284619).
- S. Monitoring UI/ Live Viewing/ Record Playback:
 1. Provide Monitoring UI/Live Viewing/Record Playback stations as provided in drawings and risers.
 2. Provide with graphical maps which show all cameras throughout the facility.

2.11 NETWORK VIDEO SYSTEM WORKSTATION

- A. Manufacturers:
 1. Dell
 2. HP
 3. Lenovo
 4. Approved Equal
- B. Workstation:

1. Chassis: Small Form Factor Workstation
2. Power Supply: 260 W, 90% efficient chassis
3. Hard Drive: M.2 SSD 256GB
4. USB standard keyboard
5. USB optical scroll mouse
6. Processor: Core i7 (3.6 GHz/25 MB/ 12C CPU)
7. Memory: 16 GB (2 x 8 GB) DDR4 Registered RAM
8. NVIDIA® Quadro® Series GPU
9. Microsoft Windows 10 Professional Edition, 64-bit OS

2.12 PoE SURGE SUPPRESSION

A. Manufacturers:

1. Transtector
2. Approved Equal

B. Surge Protection Device:

1. Connectors: RJ-45
2. Data Protocols: Gigabit Ethernet/PoE+
3. Data Rate: 1000 Mb/s
4. Protection Modes: L-G
5. Surge Protection Technology: GDT
6. VDC Rating: 48 – 60 Vdc

2.13 MEDIA CONVERTER W/PoE

A. Manufacturers:

1. BlackBox
2. Approved Equal

B. Media Converter:

1. Connectors: LC Fiber / RJ-45 Device Ports
2. Data Protocols: Single Mode Fiber / Gigabit Ethernet/PoE+
3. Data Rate: 1000 Mb/s
4. Hardened/Industrial Applications
5. Operating Temp. Range: 32° F - 158° F
6. UTP Ports: Auto-sensing

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN, WAN, and IP network and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 COORDINATION

- A. Coordinate all fiber optic and UTP cable with the communications design, including cable type, connector type, and port assignments.
- B. Contractor shall coordinate all power supplies, wiring, sources, voltage levels, surge protection, fusing and over-current protection with the electrical and the video surveillance management system equipment manufacturer's requirements.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

- A. Provide detailed Project planning forms including but not limited to the following:
 - 1. For each location, record setup of camera recording requirements.
 - 2. Prepare a specific plan for system testing, startup, and demonstration.
 - 3. Develop acceptance test concept and, on approval, develop specifics of the test.
 - 4. Develop cable and asset-management system details in accordance with Owner standards.
- B. Certified Security Contractor through the manufacturer, shall be responsible for the video surveillance management system programming, using the direction and requirements provided by the Owner, and under the Owner's supervision. Programming shall be completed on-site. Video Surveillance management system programming and software-related actions shall include but not be limited to the following:
 - 1. Proper licensing and updates to video management server(s).
 - 2. Check for prerequisites and install as needed.
 - 3. Add Sites and setup of camera views for network video workstations
 - 4. Add Logical Devices
 - 5. Assign Action Messages (if required).
 - 6. Add user permissions for personnel.
 - 7. Alarm and video call-up integration with sub-systems
 - 8. Configure Archives
 - 9. Configure Backups

- C. All programming parameters shall be presented to the Owner in advance for review and comment.

3.4 WIRING AND CABLING

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Wiring Method: Install cables in raceways unless otherwise indicated.
 - 1. Except raceways are not required in accessible indoor ceiling spaces and attics.
 - 2. Except raceways are not required in hollow gypsum board partitions.
 - 3. Conceal raceways and wiring except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. 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.
- E. For LAN connection and fiber-optic and copper communication wiring, comply with Section 271313 "Communications Copper Backbone Cabling" Section 271323 "Communications Optical Fiber Backbone Cabling" Section 271333 "Communications Coaxial Backbone Cabling" and Section 271500 "Communications Horizontal Cabling."
- F. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
 - 2. Suspend cable not in a wireway or pathway a minimum of 8 inches above ceiling by cable supports not more than 60 inches apart.
 - 3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
- G. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.5 CABLE APPLICATION

- A. Comply with TIA 569-E, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. IP Video Surveillance Cameras:
 - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.

2. Network cables not to be installed at a distance beyond the manufacturer's specification, typically 328 ft (100m).
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the IP video surveillance camera.

3.6 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Where undefined by codes and standards. Security Contractor shall apply a safety factor of at least two times the rated load of all fastenings and supports for the system components.
- B. Install cameras and infrared illuminators level and plumb.
- C. The Security Contractor shall install all system components including furnished equipment in accordance with the manufacturer's instructions, and shall furnish all cables, connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.
- D. Install cameras with 84-inch minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- E. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls, and thermal imaging, and adjust.
- F. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- G. Avoid ground loops by making ground connections only at the control station.
- H. The Contractor shall include a visual inspection of all installations to verify that the installations are in accordance with the Owner's designated representative and the manufacturer's specifications. Signed and dated records of inspections shall be provided by the contractor to the Owner's designated representative. The Owner shall be notified by the Contractor of any inspections and the Owner's designated representative may elect to participate in any inspection(s).
- I. IP Video Surveillance Cameras: IP video surveillance cameras shall be mounted to the backboxes provided for them, and attached using security fasteners. Backboxes shall be provided with a mud ring.
- J. Identify system components, wiring, cabling, and terminals according to Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.

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

D. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - a. Prepare equipment list described in "Action Submittals" Article.
 - b. Verify operation of auto-iris lenses.
 - c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. Verify operation of control-station equipment.
3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

E. Video surveillance management system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:

1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance management system.

5. Provide a written report of adjustments and recommendations.

3.9 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 282300

SECTION 284600 - FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm system control units.
2. Dedicated function control units.
3. Fire-alarm remote annunciators.
4. Fire-alarm auxiliary power supplies.
5. Fire-alarm audio amplifiers.
6. Fire-alarm terminal cabinets.
7. Manual fire-alarm boxes.
8. Heat-sensing fire detectors.
9. Smoke-sensing fire detectors.
10. Combination, multi-criteria, and multi-sensor detectors.
11. Sprinkler waterflow alarm-initiating devices.
12. Audible notification appliances.
13. Visual notification appliances.
14. Combination audible/visual notification appliances.
15. Firefighters' two-way, in-building wired telephone communications system.
16. Fire-alarm supervised control module interfaces for fire safety functions.
17. Fire-alarm supervisory signal-initiating devices.
18. Fire-alarm digital alarm communicator transmitters.
19. Fire-alarm radio alarm transmitters.
20. Fire-alarm record documentation cabinets.
21. Passive graphic maps.
22. Fire-alarm cables.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 087100 "Door Hardware" specifies door hardware control interfaces referenced by this Section.
6. Section 142100 "Electric Traction Elevators" specifies elevator control interfaces referenced by this Section.
7. Section 230923 "Direct Digital Control (DDC) System for HVAC" specifies HVAC control interfaces referenced by this Section.
8. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.

9. Section 260533.13 "Conduits for Electrical Systems" specifies raceway types installed by this Section.
10. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration isolation and seismic and wind control devices referenced by this Section.
11. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
12. Section 260923 "Lighting Control Devices" specifies emergency lighting control interfaces referenced by this Section.
13. Section 262816 "Enclosed Switches and Circuit Breakers" specifies shunt-trip control interfaces referenced by this Section.
14. Section 270528 "Pathways for Communications Systems" specifies additional requirements for raceway materials, routing, locations, and identification of communications equipment and cabling.
15. Section 275119 "Sound Masking Systems" specifies sound masking system equipment referenced by this Section.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. AWG: American wire gauge; see ASTM B258.
2. BAS: Building automation system.
3. BMS: Building management system.
4. cd: Candela, the SI fundamental unit of luminous intensity.
5. DACR: Digital alarm communicator receiver.
6. DACT: Digital alarm communicator transmitter.
7. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
8. EMP: Electrical maintenance program (operation and maintenance); electromagnetic pulse (transient analysis).
9. EPS: Emergency power supply.
10. EPSS: Emergency power supply system.
11. ERCES: Emergency responder communications enhancement system.
12. ESS: Energy storage system.
13. FACU: Fire-alarm control unit.
14. FAS: Fire-alarm system.
15. IDC: Initiating device circuit.
16. IP: Internet Protocol.
17. IR: Infrared.
18. LAN: Local area network.
19. LCD: Liquid-crystal display.
20. LED: Light-emitting diode.
21. Li-ion: Lithium-ion.
22. NAC: Notification appliance circuit.
23. N.C.: Normally closed.
24. Ni-Cd: Nickel-cadmium.
25. Ni-MH: Nickel-metal hydride.
26. N.O.: Normally open.
27. PC: Personal computer.
28. PLFA: Power-limited fire alarm.
29. PoE: Power over Ethernet.
30. POTS: Plain old telephone service. See "public switched telephone network" definition.
31. PSTN: Public switched telephone network.

32. RAT: Radio alarm transmitter.
33. SLC: Signaling-line circuit.
34. TR: Tamper resistant.
35. UL: (standards) UL Standards & Engagement Inc.; (product categories) UL Solutions, Inc.
36. UL CCN: UL Category Control Number.
37. UPS: Uninterruptible power supply.
38. VoIP: Voice over Internet Protocol.
39. VPN: Virtual private network.
40. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
41. WAN: Wide area network.
42. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types: See 260533.13.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. CI: Circuit integrity cable.
2. FPL: Power-limited fire-alarm cable.
3. FPLP: Power-limited fire-alarm plenum cable.
4. FPLR: Power-limited fire-alarm riser cable.
5. MC-FPL/FPLR/FPLP: Metal-clad cable containing FPL, FPLR, or FPLP.
6. NPLF: Non-power-limited fire-alarm circuit cable.
7. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
8. NPLFR: Non-power-limited fire-alarm circuit riser cable.
9. OFC: Conductive optical fiber general-purpose cable.
10. OFCG: Conductive optical fiber general-purpose cable.
11. OFCP: Conductive optical fiber plenum cable.
12. OFCR: Conductive optical fiber riser cable.
13. OFN: Nonconductive optical fiber general-purpose cable.
14. OFNG: Nonconductive optical fiber general-purpose cable.
15. OFNP: Nonconductive optical fiber plenum cable.
16. OFNR: Nonconductive optical fiber riser cable.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For fire-alarm system coordination with the sound-masking system and paging system. Conduct meeting(s) as videoconference before installation begins.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect of scheduled meeting dates.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

- a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
 - b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
 - c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.
 2. Include manufacturer's sample extended warranty language.
- B. Shop Drawings: Prepare and submit the following:
 1. Cover sheet indicating protected premises name and location and Owner information, name of installer, device legend and symbols acceptable to the authorities having jurisdiction, and date of issue and any revision dates.
 2. Floor Plans:
 - a. Floor or level identification.
 - b. Point of compass (indication of north).
 - c. Graphic scale.
 - d. All walls and doors.
 - e. All partitions extending to within 15 percent of the ceiling height.
 - f. Room and area descriptions.
 - g. Acoustically distinguishable spaces.
 - h. Minimum required illumination levels.
 - i. System devices/component locations.
 - j. Locations of the system's primary power disconnecting means.
 - k. Locations of monitor/control interfaces to other systems.
 - l. System riser locations.
 - m. Type and number of system components/devices on each circuit, on each floor or level.
 - n. Type and quantity of conductors for each circuit.
 - o. Identification of any ceiling over 10 ft (3.0 m) in height where automatic fire detection is being proposed.
 - p. Details of ceiling geometries, including beams and solid joists, where automatic fire detection is being proposed.
 - q. Acoustic properties of spaces, where known.
 - r. Pathway class designations, including the location of any end-of-line supervisory or power devices that are required by the pathway class.
 - s. Pathway survivability level designations.
 3. Wiring Diagrams:
 - a. System riser diagrams coordinated with the floor plans and indicating the following information:
 - 1) General arrangement of the system in building cross-section.
 - 2) Number of risers.
 - 3) Type and number of circuits in each riser.
 - 4) Type and number of system components/devices on each circuit, on each floor or level.
 - 5) Number of conductors for each circuit.

- 6) Pathway class designation, including the location of any end-of-line supervisory or power devices that are required by the pathway class.
 - 7) Pathway survivability level designations.
 - b. Control unit diagrams for all control equipment, power supplies, battery chargers, and annunciators indicating the following information:
 - 1) Identification of control equipment depicted.
 - 2) Location(s) of control equipment.
 - 3) All field wiring terminals and terminal identifications.
 - 4) All circuits connected to field wiring terminals and circuit identifications.
 - 5) All indicators and manual controls.
 - 6) Field connections to supervising station signaling equipment, **releasing** equipment, and emergency safety control interfaces.
 - c. Typical fire-alarm component schematic wiring diagrams for all initiating devices, notification appliances, remote indicators, remote test stations, end-of-line and power supervisory devices, and annunciators.
- 4. Fire-Alarm Input/Output Sequence: Include a narrative description or input/output matrix of operation to describe the fire-alarm system sequence of operation.
- 5. Details:
 - a. Component installation details.
 - b. Custom graphic annunciator layout.
- 6. Calculations:
 - a. Battery calculations.
 - b. Voltage-drop calculations.
 - c. Speaker circuit calculations.
 - d. Spare capacity circuit calculations.
- C. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A. Manufacturer's published instructions.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for software and firmware upgrades.

1.6 CLOSEOUT SUBMITTALS

- A. Warranty documentation.
- B. Maintenance service agreement.
- C. Software and firmware service agreement.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare parts.
- B. Special tools.

1.8 REGULATORY AGENCY APPROVALS

- A. Submittals for fire detection and alarm system requiring approval by authorities having jurisdiction must be signed by qualified NICET FAS senior engineering technician or life-safety professional engineer responsible for their preparation. Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.

1.9 QUALIFICATIONS

- A. Fire-Alarm Systems (FAS) Technician Trainee: Having at least six months of experience and possessing active NICET FAS Level I certification. Able to perform limited tasks under direct supervision.
- B. Fire-Alarm Systems (FAS) Associate Engineering Technician: Having at least two years of experience and possessing active NICET FAS Level II certification. Able to review drawings, specifications, codes, and standards; to conduct basic installation activities; and to perform basic troubleshooting.
- C. Fire-Alarm Systems (FAS) Engineering Technician: Having at least five years of experience and possessing active NICET FAS Level III certification. Able to perform system layout activities, supervise Level I and Level II technicians, provide submittal packages, and interact with authorities having jurisdiction.
- D. Fire-Alarm Systems (FAS) Senior Engineering Technician: Having at least 10 years of experience and possessing active NICET FAS Level IV certification. Able to manage multiple projects at once, interpret codes and standards, conduct training, and serve as liaison between authorities having jurisdiction, owners, engineers, and contractors.
- E. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician I: Possessing active NICET I&TFAS Level I certification. Able to perform periodic inspections and tests of basic fire-alarm systems and prepare related records and reports.
- F. Inspection and Testing of Fire-Alarm Systems (I&TFAS) Technician II: Possessing active NICET I&TFAS Level II certification. Able to plan, perform, and coordinate periodic inspections and tests of complex fire-alarm systems (including one or more of suppression interfaces, networked control units, smoke control interfaces, air sampling systems, multi-zone voice evacuation systems, or high-rise applications) and prepare related records and reports.
- G. Life-Safety Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in life-safety systems.
- H. Fire-Alarm Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate fire-alarm cabling.

1. On-site fire-alarm cable installation supervisor must possess active NICET FAS Engineering Technician certification.
- I. Fire-Alarm Testing Agency: Entity possessing active credentials from qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site fire-alarm testing supervisor must possess active NICET I&TFAS Technician I certification.

1.10 WARRANTY FOR FIRE DETECTION AND ALARM SYSTEMS

- A. Special Installer Extended Warranty: Installer warrants that installed fire detection and alarm system performs in accordance with specified requirements and agrees to repair or replace system components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that fire detection and alarm system components perform in accordance with specified requirements and agrees to repair or replace system components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.
 1. Initial Extended-Warranty Period: Three years from date of Substantial Completion; prorated coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70 or NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. System Description: Noncoded, UL-certified addressable system with multiplexed signal transmission and \voice\ and-strobe notification for evacuation.
- C. System Inputs:
 1. Fire-alarm signal initiation must be by one or more of the following devices and systems:
 - a. Manual fire-alarm boxes.
 - b. Heat detectors.
 - c. Smoke detectors.
 - d. Duct smoke detectors.
 - e. Air-sampling smoke-detection system.
 - f. Automatic sprinkler system water flow.
 - g. Preaction system alarm.
 - h. Fire-extinguishing system operation.
 - i. Fire standpipe system.

- j. Dry-pipe sprinkler system pressure flow switch.
 - k. Fire pump is running.
2. Supervisory signal initiation must be by one or more of the following devices and actions:
- a. Valve supervisory switch.
 - b. High- or low-air pressure switch of dry-pipe or preaction sprinkler system.
 - c. Alert and Action signals of air-sampling smoke-detection systems.
 - d. Duct smoke detectors.
 - e. Elevator shunt-trip control circuit supervision.
 - f. Independent fire-detection and fire-suppression systems.
 - g. Fire pump is running.
 - h. Fire pump has lost power.
 - i. Power to the fire pump has phase reversal.
 - j. Zones or individual devices have been disabled.
 - k. FACU has lost communication with network.
 - l. Hose cabinet door is open.
3. System trouble signal initiation must be by one or more of the following devices and actions:
- a. Open circuits, shorts, and grounds in designated circuits.
 - b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - c. Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, or ethernet module.
 - d. Loss of primary power at FACU.
 - e. Ground or single break in internal circuits of FACU.
 - f. Abnormal AC voltage at FACU.
 - g. Break in standby battery circuitry.
 - h. Failure of battery charging.
 - i. Abnormal position of switch at FACU or remote annunciator.
 - j. Voice signal amplifier failure.
- D. System Outputs:
1. Fire-alarm signal must initiate the following actions:
- a. Continuously operate alarm notification appliances, including voice evacuation notices.
 - b. Identify alarm and specific initiating device at FACU, connected network control panels, off-premises network control panels and remote annunciators.
 - c. Transmit alarm signal to remote alarm receiving station.
 - d. Unlock electric door locks in designated egress paths.
 - e. Release fire and smoke doors held open by magnetic door holders.
 - f. Activate voice/alarm communication system.
 - g. Switch HVAC equipment controls to fire-alarm mode.
 - h. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - i. Activate preaction system.
 - j. Recall elevators to designated or alternate recall levels only upon activation of smoke detectors in respective elevator lobbies, machine rooms, or hoistways.
 - k. Activate elevator power shunt trip only upon activation of associated heat detector.
 - l. Activate emergency lighting control.
 - m. Record events in system memory.
 - n. Indicate device in alarm on graphic annunciator.

2. System supervisory signal must initiate the following actions:
 - a. Initiate supervisory notification appliances.
 - b. Identify specific device initiating event at FACU, connected network control panels, off-premises network control panels, and remote annunciators.
 - c. After time delay of 200 seconds, transmit trouble or supervisory signal to remote alarm receiving station.
 - d. Transmit system status to building management system.
 - e. Display system status on graphic annunciator.

2.2 FIRE-ALARM SYSTEM CONTROL UNITS

- A. Description: A component of the fire-alarm system, provided with primary and secondary power sources, which receives signals from initiating devices or other fire-alarm control units, and processes these signals to determine part or all of the required fire-alarm system output functions.
- B. UL UOJZ - Addressable Fire-Alarm System Control Units:
 1. Acceptable Manufacturers:
 - a. Siemens
 - b. Notifier
 - c. Simplex
 - d. Autocall
 - e. EST
 2. Source Limitations: Obtain products from single manufacturer.
 3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electrical Control Units for Fire-Protective Signaling Systems: UL CCN UOJZ, including UL 864 and NFPA 72.
 4. Standard Features:
 - a. Product Reference Standards: Ch. 23 of NFPA 72.
 - b. Voice/alarm communications.
 - c. Indication of which communication zones have been silenced.
 - d. Provide selective silencing of alarm notification appliances by building communication zone.
 - e. Real-time clock for time annotation of events on the event recorder.
 - f. Communication between the FACU and remote circuit interface panels, annunciators, and displays.
 - g. The FACU must be listed for connection to a central station signaling system service.
 - h. Provide non-volatile memory for system database, logic, operating system, and event history.
 - i. The system must not require manual input to initialize in the event of a complete power-down condition.
 - j. Alphanumeric display and system controls.
 - k. Minimum of four Class A signaling-line circuits with expansion capability to add circuits.
 - l. Minimum of four Class A notification appliance circuits with expansion capability to add circuits.
 - m. Synchronization of notification appliance circuits.

2.3 DEDICATED FUNCTION CONTROL UNITS

- A. Description: A protected premises fire-alarm control unit specifically listed for supervising a single function, such as releasing service that is part of a fire-suppression system and which provides control outputs to release a fire-suppression agent based on either automatic or manual input.
- B. UL SYZV - Addressable Non-Extinguishing and Non-Water-Based Releasing Device Control Unit:
 - 1. Source Limitations: Obtain products from single manufacturer of Addressable Fire-Alarm System Control Unit.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Releasing Device Control Units for Fire-Protective Signaling Systems: UL CCN SYZV, including UL 864 and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 23 of NFPA 72.
 - b. Built-in alarm, trouble, supervisory, and security relays.
 - c. Minimum of four Class A signaling-line circuits with expansion capability to add circuits.
 - d. Auto programming and walk test reports.
 - e. Manual sensitivity adjustments.
 - f. Maintenance alerts.
 - g. Battery charger supports.
 - h. Non-alarm points for lower-priority functions.
 - 4. Other Available Features Required by Project:
 - a. Printer interface.
 - b. Synchronization of notification appliance circuits.

2.4 FIRE-ALARM REMOTE ANNUNCIATORS

- A. Description: A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a fire-alarm system device, circuit, condition, or location.
- B. UL UOXX - Fire-Alarm System Remote Annunciators:
 - 1. Source Limitations: Obtain products from single manufacturer of Addressable Fire-Alarm System Control Unit.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
 - 3. Standard Features:

- a. Product Reference Standards: Ch. 23 of NFPA 72.
- b. Compatibility with fire-alarm control unit for alphanumeric display and LED indicating lights.
- c. Provide controls to acknowledge, silence, reset and test functions for alarm, supervisory, and trouble signals.

2.5 FIRE-ALARM AUXILIARY POWER SUPPLIES

- A. Description: An auxiliary source of low-voltage electrical operating power for fire-alarm system equipment, including the circuits and terminations connecting it to the equipment being powered. Auxiliary power supplies are often referred to as remote power supplies, booster power supplies, or notification appliance power supplies.
- B. UL UOXX - Fire-Alarm Auxiliary Power Supplies:
 - 1. Source Limitations: Obtain products from single manufacturer of Addressable Fire-Alarm System Control Unit.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Chs. 10 and 23 of NFPA 72.
 - b. Minimum of four 24 V(dc) auxiliary power circuits.
 - 4. Other Available Features Required by Project:
 - a. Synchronization of notification appliance circuits.
 - b. Addressable-type notification appliance power supply, which connects directly to a signaling-line circuit.

2.6 FIRE-ALARM AUDIO AMPLIFIERS

- A. Description: A component of in-building fire emergency voice/alarm communications systems that takes a low-level audio input and amplifies the power output to distribute to fire-alarm loudspeakers. Amplifiers can be an integral component of the fire-alarm control unit or can be remotely located in a separate cabinet within the building.
- B. UL UEAY2 - Fire-Alarm Audio Amplifiers:
 - 1. Source Limitations: Obtain products from single manufacturer of Addressable Fire-Alarm System Control Unit.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Amplifiers for Fire-Protective Signaling Systems: UL CCN UEAY2, including UL 1711, UL 1480, UL 1480A, UL 864, and NFPA 72.

3. Standard Features:
 - a. Product Reference Standards: Chs. 18, 23, and 24 of NFPA 72.
 - b. Supervised high-fidelity audio for emergency voice evacuation fire-alarm systems.
 - c. Frequency Response: 275 Hz - 6.5 kHz.
 - d. Speaker Outputs: 25 Vpower limited.
 - e. Minimum of fourClass Aspeaker output circuits.
4. Other Available Features Required by Project:
 - a. Minimum of fourClass Asynchronized strobe power circuits.
 - b. Eight digitally pre-recorded voice messages.
 - c. Push-to-Talk (PTT) microphone.

2.7 FIRE-ALARM TERMINAL CABINETS

- A. Description: A cabinet with hinged, lockable cover clearly labeled and intended for termination of fire-alarm conductors at junction points. Screw-type terminal blocks are provided within the terminal cabinet for conductor splices.
- B. UL UOXX - Fire-Alarm Terminal Cabinet:
 1. Source Limitations: Obtain products from single manufacturer of Addressable Fire-Alarm System Control Unit.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. System Control Unit Accessories: UL CCN UOXX, including UL 864 and NFPA 72.
 3. Standard Features:
 - a. Labeled "FIRE ALARM TERMINAL CABINET."
 - b. Interior field identification labels.
 - c. Sized accordingly to contain required number of termination points.
 - d. Accessible by authorized personnel only.

2.8 MANUAL FIRE-ALARM BOXES

- A. Description: A manually operated device used to initiate a fire-alarm signal. Manual fire-alarm boxes come in both conventional or addressable models and may require a single-action (pull down) or double-action (push in and pull down) to initiate a fire-alarm signal. These initiating devices are sometimes referred to as manual fire-alarm stations, pull stations, or call points.
- B. UL UNIU - Single-Action Manual Fire-Alarm Boxes:
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Non-Coded Fire-Alarm Boxes: UL CCN UNIU, including UL 38 and NFPA 72.

3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Colored red with raised letters providing operating instructions.
 - c. Surfacemounted.
 - d. Station Reset: Key operated switch.
 - e. Material: Polycarbonate.

2.9 HEAT-SENSING FIRE DETECTORS

- A. Description: A fire detector that detects either abnormally high temperatures or rate-of-temperature rise, or both.
- B. UL UQGS - Fixed-Temperature Heat Detectors:
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Heat-Detecting-Type Automatic Fire Detectors: UL CCN UQGS, including UL 521 and NFPA 72.
 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Actuated by temperature that exceeds fixed temperature of 135 deg F (57 deg C) regardless of rate of temperature rise.
 - c. Addressable-type initiating device.
 - d. Detector must have functional humidity range of 10 to 90 percent.

2.10 SMOKE-SENSING FIRE DETECTORS

- A. Description: A device that detects visible or invisible particles of combustion and initiates an action. Types of smoke-sensing fire detectors include spot-type detectors, air-sampling detectors, projected beam-type detectors, duct detectors, multi-criteria detectors, and video image smoke detectors.
- B. UL UROX - Spot-Type Smoke Detectors:
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Field programmable.

- c. Resettable from the control unit.
- d. Removable from the base assembly without the use of tools and without disturbing the wiring connections.
- e. Sensing Type: Photoelectric.

C. UL UROX - Air Sampling-Type Smoke Detectors:

- 1. Source Limitations: Obtain products from single manufacturer.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
- 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Piping system and fan to transport particles of combustion to detector chamber.
 - c. Detectors must communicate with FACU via addressable smoke detector installed in housing and interface modules.
 - d. Pipe length and hole sizes must be in accordance with manufacturer's published instructions
 - e. Detector and Aspirator: Housed in mounting box and arranged such that air is drawn from detection area and sample passes through detector chamber.
 - f. Detector must transmit faults to the FACU.

D. UL UROX - Duct Smoke Detectors:

- 1. Source Limitations: Obtain products from single manufacturer.
- 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Detectors Designed for Smoke Particles: UL CCN UROX, including UL 268 and NFPA 72.
- 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
 - c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - d. Integral Visual-Indicating Light: LED type, indicating detector has operated.
 - e. Detectors must be four- or two-wire type.
 - f. Detector address must be accessible from fire-alarm control unit and must be able to identify the detector's location within the system and its sensitivity setting.
 - g. Operator at FACU, having designated access level, must be able to manually access the following for each detector: primary status, device type, present average value, present sensitivity selected, and sensor range.

2.11 SPRINKLER WATERFLOW ALARM-INITIATING DEVICES

- A. Description: An initiating device used to monitor the flow of water in a wet-pipe or dry-pipe sprinkler system for the purpose of initiating an alarm signal. These devices employ operating mechanisms that include paddle operation, pressure operation, or mechanical operation.
- B. UL USQT - Sprinkler Waterflow Alarm-Initiating Device:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Activation of the initiating device occurs within 90 seconds of waterflow at the alarm-initiating device when flow occurs that is equal to or greater than that from a single sprinkler of the smallest orifice size installed in the system.
 - c. Movement of water due to waste, surges, or variable pressure must not initiate an alarm signal.
 - d. Adjustable time delay.
 - e. Pressure Range: 20 to 175 psig (1.38 to 12.07 bar).

2.12 AUDIBLE NOTIFICATION APPLIANCES

- A. Description: A fire-alarm system component such as a horn or loudspeaker that provides audible output to alert occupants by the sense of hearing.
- B. UL UUMW - Loudspeakers:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Speakers and Amplifiers Used in Fire-Alarm and/or Emergency Communication Systems: UL CCN UUMW, including UL 1480 and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Flush and ceiling-tile mounting with use of ceiling tile brackets.
 - c. Field-selectable voltage and power tap settings.
 - d. Operating Temperature Range: 32 deg F to 120 deg F (0 deg C to 50 deg C).
 - e. Compatible with wires up to 12 AWG.

2.13 VISUAL NOTIFICATION APPLIANCES

- A. Description: A fire-alarm system component that provides a visible output to alert occupants by the sense of sight, including visual strobes.
- B. UL UVAV - Strobe:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Visual-Signal Appliances for Fire-Protective Signaling Applications: UL CCN UVAV, including UL 1638 and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Operating Temperature Range: 32 deg F to 120 deg F (0 deg C to 50 deg C).
 - c. Compatible with wires up to 12 AWG.
 - d. Rated Light Output: 15, 30, 75, or 110] candela.
 - e. Field-selectable candela settings.
 - f. Clear polycarbonate lens mounted on faceplate.
 - 4. Other Available Features Required by Project:
 - a. Weather resistant to provide protection against water, humidity, and corrosion.

2.14 COMBINATION AUDIBLE/VISUAL NOTIFICATION APPLIANCES

- A. Description: A fire-alarm system component such as a horn/strobe or loudspeaker/strobe that provides both an audible and a visible output to alert occupants by the sense of hearing and sight.
- B. UL UUMW and UVAV - Combination Loudspeaker/Strobe Appliances:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Electrically Operated Signal-Sounding Appliances or Visual-Signal Appliances for Fire-Protective Signaling Applications: UL CCN UUMW and UVAV, including UL 1480, UL 1638, and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 18 of NFPA 72.
 - b. Operating Temperature Range: 32 deg F to 120 deg F.
 - c. Compatible with wires up to 12 AWG.
 - d. Rated Light Output: 15, 30, 75, or 110 candela.
 - e. Clear polycarbonate lens mounted on faceplate.
 - f. Strobe flash rate of 1 Hz over its entire operating range.
 - g. Field-selectable candela settings.
 - h. Field-selectable voltage and power settings.

- i. Universal mounting plate for ceiling units.
- 4. Accessories:
 - a. Combination audible/visual appliance protective guard.
 - b. Weather resistant to provide protection against water, humidity, and corrosion.

2.15 FIREFIGHTERS' TWO-WAY, IN-BUILDING WIRED TELEPHONE COMMUNICATIONS SYSTEM

- A. Description: A two-way in-building telephone communications system used by firefighters and emergency response personnel when responding to, investigating, and conducting rescue activities in a fire incident.
- B. Firefighters' Two-Way, In-Building Wired Telephone Communications System:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one or more of the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
 - b. Control Units, System: UL CCN UOJZ, including UL 864 and NFPA 72.
 - c. Control Units, Releasing Device: UL CCN SYZV, including UL 864 and NFPA 72, in addition to standards related to suppressant or energy storage system being released.
 - d. Control and Communications Equipment: UL CCN PGWM, including UL 2572 and NFPA 72.
 - e. Smoke Control System Equipment: UL CCN UUKL, including UL 864, NFPA 72, and NFPA 92.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 24 of NFPA 72.

2.16 FIRE-ALARM SUPERVISED CONTROL MODULE INTERFACES FOR FIRE SAFETY FUNCTIONS

- A. Description: An addressable fire-alarm control module that interfaces to another building system for the purpose of initiating an action for that system based upon activation of a supervisory or alarm condition on the fire-alarm system. The interface between the control module and the other building system or equipment is supervised.
- B. UL UOXX - Fire-Alarm Supervised Control Module:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

- a. Control Unit Accessories - Addressable Control Modules: UL CCN UOXX, including UL 864 and NFPA 72.
- 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Field programmable.
 - c. Resettable from the control unit.
 - d. Supervises Class A initiating device circuits.
 - e. Capable of interfacing with the following systems:
 - 1) Elevator controller.
 - 2) Elevator power shunt-trip.
 - 3) Elevator shunt-trip power monitoring.
 - 4) HVAC line voltage.
 - 5) Building management system.
 - 6) Magnetic door hold-open circuits.
 - 7)
 - 8) Door-release.
 - 9) Electrically locked doors.

2.17 FIRE-ALARM SUPERVISORY SIGNAL-INITIATING DEVICES

- A. Description: An initiating device such as a valve supervisory switch, water-level indicator, low-air-pressure switch, or low-temperature switch in which the change of state signals to the fire-alarm control unit an off-normal condition and its restoration to normal of a fire-protection or life-safety system; or a need for action in connection with guard tours, fire-suppression systems or equipment, or maintenance features of related systems.
- B. UL USQT - Control Valve Supervisory Signal-Initiating Devices:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.
 - 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiation of two separate and distinct signals; one indicating movement of the valve from its normal position, and the other indicating restoration of the valve to its normal position.
 - c. Off-normal signal must be initiated during the first two revolutions of the handwheel, or during one-fifth of the travel distance of the valve from its normal position.
 - d. Off-normal signal must not be restored at any valve position except normal.
- C. UL USQT - Pressure-Monitoring/Supervisory Signal-Initiating Devices:
 - 1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346, and NFPA 72.
 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiation of two separate and distinct signals; one indicating that the required pressure has increased or decreased (off-normal), and the other indicating restoration of the pressure to its normal value.
- D. UL USQT - Fire Pump Supervisory Signal-Initiating Devices:
1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Extinguishing System Attachments: UL CCN USQT, including UL 346 and NFPA 72.
 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiates a supervisory signal for any off-normal conditions of a fire pump, including the following:
 - 1) Fire pump running.
 - 2) Fire pump loss of power.
 - 3) Fire pump phase reversal.
- E. UL UOXX - Generator Supervisory Signal-Initiating Devices:
1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. System Control Unit Accessories: UL CCN UOXX, including UL 864 and NFPA 72.
 3. Standard Features:
 - a. Product Reference Standards: Ch. 17 of NFPA 72.
 - b. Initiates a supervisory signal upon indication of generator running condition.

2.18 FIRE-ALARM DIGITAL ALARM COMMUNICATOR TRANSMITTERS

- A. Description: A fire-alarm system component at the protected premises to which the fire-alarm control unit connects and transmit signals indicating a status change of initiating devices or groups

of devices. The DACT seizes the connected cellular signal, dials a preselected number to connect to a DACR, and transmits signals indicating a status change of the initiating devices.

B. UL UOXX - Fire-Alarm Digital Alarm Communicator Transmitter:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Control Unit Accessories for Fire-Protective Signaling Systems: UL CCN UOXX, including UL 864 and NFPA 72.
3. Standard Features:
 - a. Product Reference Standards: Ch. 26 of NFPA 72.
 - b. Compatible with remote alarm receiving station receiver.
 - c. Receive alarm, supervisory, or trouble signals from FACU and automatically transmit to remote alarm receiving station via cellular network.
 - d. Indicate trouble signal at FACU upon loss of communication with the remote alarm receiving station.
 - e. Indicate local trouble signal upon loss of communication with the FACU.
 - f. Secondary Power: Integral rechargeable battery and automatic charger.
 - g. Digital data transmission of the following signals:
 - 1) Address of alarm-initiating device.
 - 2) Address of supervisory signal.
 - 3) Address of trouble-initiating device.
 - 4) Loss of AC supply.
 - 5) Loss of power.
 - 6) Low battery.
 - 7) Abnormal test signal.
 - 8) Communication bus failure.
 - h. Self-test automatically performed every 24 hours with report transmitted to remote alarm receiving station.

2.19 FIRE-ALARM RECORD DOCUMENTATION CABINETS

- A. Description: A cabinet clearly labeled and intended for the storage of fire-alarm record documents, including as-built drawings; programming documentation; and inspection, testing, and maintenance documentation.
- B. UL UOXX - Fire-Alarm-System Record-Documents Storage Cabinet:
 1. Source Limitations: Obtain products from single manufacturer.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. System Control Unit Accessories: UL CCN UOXX, including UL 864 and NFPA 72.
 3. Standard Features:

- a. Labeled "SYSTEM RECORD DOCUMENTS."
- b. Sized accordingly to contain all necessary documentation.
- c. Accessible by authorized personnel only.

2.20 PASSIVE GRAPHIC MAPS

- A. Description: A printed graphic map showing building floor plans indicating initiating device locations and control equipment locations for use by emergency responders and maintenance personnel.
- B. Fire-Alarm Passive Graphic Map
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. H.R. Kirkland Co, .
 2. Source Limitations: Obtain products from single manufacturer.
 3. Standard Features:
 - a. Product Reference Standards: Ch. 7 of NFPA 72.
 - b. Indicates initiating device type, locations, and corresponding addresses.
 - c. Indicates control equipment locations.
 - d. Mounted in a plexiglass frame adjacent to the FACU.
 - e. Legible and sized accordingly.

2.21 FIRE-ALARM CABLES

- A. UL HNIR - Power-Limited Fire-Alarm Cable (FPL):
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Belden
 - b. Southwire
 - c. West Penn
 - d. Radix
 2. Listing Criteria:
 - a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
 3. Standard Features:
 - a. Solidcopper conductors with 300 V rated, 75 deg C, color-coded insulation.
- B. UL HNIR - Power-Limited Fire-Alarm Plenum Cable (FPLP):
 1. See FPL above.
 2. Listing Criteria:

- a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
 - d. Plenum Rating: NFPA 262
 - 3. Standard Features:
 - a. Solid copper conductors with 300 V rated, 75 deg C, color-coded insulation.
- C. UL HNIR - Power-Limited Fire-Alarm Riser Cable (FPLR) <Insert drawing designation>:
- 1. See FPL above.
 - 2. Listing Criteria:
 - a. Power-Limited Fire-Alarm Cable: UL CCN HNIR; including UL 1424 and Article 760 of NFPA 70.
 - b. Vertical-Tray Flame Test: UL 1685.
 - c. Limited Smoke "ST1" Marking: UL 1685 or UL 2556.
 - d. Riser Rating: UL 1666.
 - 3. Standard Features:
 - a. Solid copper conductors with 300 V rated, 75 deg C, color-coded insulation.

2.22 MAINTENANCE MATERIAL ITEMS

- A. Spare Parts: Furnish to Owner spare parts, for repairing fire detection and alarm system components, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
- 1. Smoke Detectors: 5% of total.
 - 2. Heat Detectors: 5% of total.
 - 3. Duct Smoke Detectors: 5% of total.
 - 4. Manual Fire-Alarm Boxes: (4).
 - 5. Addressable Input Modules: 5% of total.
 - 6. Addressable Output Modules: 5% of total.
 - 7. Audible Notification Appliances: (4).
 - 8. Visual Notification Appliances: (4).
 - 9. Combination Audible/Visual Notification Appliances: (4).
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to fire detection and alarm system, that are packaged with protective covering for storage on-site and identified with labels describing contents.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine field conditions with Installer present for compliance with requirements for fire detection and alarm systems and other conditions affecting performance of the Work.
- B. Examine all materials, products, and equipment received for defects or damage.
- C. Reject all materials, products, and equipment that show signs of defects or damage.
- D. Examine roughing-in for fire detection and alarm system piping to verify actual locations of piping connections before equipment installation.
- E. Examine walls, floors, ceilings, and roofs for suitable conditions where fire detection and alarm system components will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF RACEWAYS FOR FIRE ALARM

- A. Refer to 260553 "Identification for Electrical Systems" for requirements on coating and coloring.
- B. Refer to 260533.13 "Conduits for Electrical Systems" for additional requirements on allowable conduit types, fittings, and installation methods.

3.3 INSTALLATION OF FIRE DETECTION AND ALARM SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Commissioning of Electrical Systems: NECA NEIS 90.
 - 3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
 - 4. Fire-Alarm and Premises Security Work: NFPA 72, NFPA 731, NFPA 1225, and NECA NEIS 305.
 - 5. Work in ITE Rooms: NFPA 75.
 - 6. Life-Safety and Means-of-Egress Work: NFPA 101.
 - 7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
 - 8. Work in Confined Spaces: NFPA 350.
 - 9.
 - 10. Fire-Alarm Circuits and Pathways: Ch. 12 of NFPA 72 and Article 760 of NFPA 70.
 - 11. Fire-Alarm Initiating Devices: Ch. 17 of NFPA 72.
 - 12. Fire-Alarm Notification Appliances: Ch. 18 of NFPA 72.
 - 13. Fire-Alarm Control Equipment: Ch. 23 of NFPA 72.
 - 14. Fire-Alarm Transmitting Equipment: Ch. 23 and Ch. 26 of NFPA 72.
 - 15. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification: Provide labels for all initiating devices, control equipment cabinets, and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Label initiating devices with unique identification.
 - c. Identify source of AC power inside each control equipment cabinet.
 - d. Identify circuit disconnecting means at AC power source with red engraved label. Provide approved locking device for circuit disconnecting means.
 - e. Label enclosures with engraved metal or laminated-plastic nameplate.
 - f. Identify junction box covers using the color red.

3.4 FIELD QUALITY CONTROL OF FIRE DETECTION AND ALARM SYSTEMS

A. Administrant for Fire-Alarm Tests and Inspections:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Perform system acceptance testing in accordance with Ch. 14[**and Appendix D**] of NFPA 72.
3. Contractor is responsible for completing pre-acceptance testing to verify proper operation of the fire detection and alarm systems. Correct system deficiencies prior to scheduling a final acceptance test.

D. Nonconforming Work:

1. Initiating devices, notification appliances, control equipment, and system accessories will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services: Engage factory-authorized service representative to supervise field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.5 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.

2. Provide power to the FACU and configure internal settings.
3. Test all field wiring prior to connecting field devices and prior to connecting to the FACU. Ensure field wiring is free from ground faults and short circuits.
4. Connect field devices to field wiring.
5. Connect field wiring inside FACU cabinet.
6. Ensure system is normal and free from ground faults, open circuits, or short circuits.
7. Allow system burn-in for 30days.
8. Correct any issues that occur during the system burn-in period.

B. Manufacturer Services: Engage factory-authorized service representative to supervise system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.6 PROTECTION

A. After installation, protect fire detection and alarm system equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.7 MAINTENANCE

A. Maintenance Service Agreement: Beginning at Substantial Completion, verify that maintenance service agreement includes one-year period for full maintenance by manufacturer's authorized service representative. Include annual preventive maintenance, repair, or replacement of worn or defective components; cleaning; and adjusting as required for proper fire detection and alarm system operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

B. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for two years
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within two years from date of Substantial Completion.
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 284600

SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Soil treatment.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components, and profiles for termite control products.
 - 2. Include the EPA-Registered Label for termiticide products.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer of termite control products.
- B. Qualification Data: For qualified Installer.
- C. Product Certificates: For each type of termite control product.
- D. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
 - 1. Date and time of application.
 - 2. Moisture content of soil before application.
 - 3. Termiticide brand name and manufacturer.
 - 4. Quantity of undiluted termiticide used.
 - 5. Dilutions, methods, volumes used, and rates of application.
 - 6. Areas of application.
 - 7. Water source for application.
- E. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located, and who is accredited by manufacturer.

1.6 FIELD CONDITIONS

- A. Soil Treatment:
 - 1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
 - 2. Related Work: Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.7 WARRANTY

- A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites, including Formosan termites (*Coptotermes formosanus*). If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
 - 1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain termite control products from single source from single manufacturer.

2.2 SOIL TREATMENT

- A. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation.
 - 1. Products: Subject to compliance with requirements, provide one of the following. No substitutions allowed.
 - a. BASF Corporation, Agricultural Products; Termidor. (Fipronil)
 - b. Bayer Environmental Science; Premise 75. (Imidacloprid)
 - 2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than ten years against infestation of subterranean termites.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label, interfaces with earthwork, slab and foundation work, landscaping, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
 - 1. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

3.3 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.
 - 1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
 - 2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
 - 3. Crawlspace: Soil under and adjacent to foundations. Treat adjacent areas, including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
 - 4. Masonry: Treat voids.
 - 5. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.
- B. Post warning signs in areas of application.
- C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.4 PROTECTION

- A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

3.5 MAINTENANCE SERVICE

- A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of termite-control-treatment Installer. Include annual maintenance as required for proper performance according to the product's EPA-Registered Label and manufacturer's written instructions. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
- B. Continuing Maintenance Proposal: Provide from termite-control-treatment Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.
 - 1. Include annual inspection for termite activity and effectiveness of termite treatment according to manufacturer's written instructions.

END OF SECTION 313116

SECTION 321316 - DECORATIVE CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Colored concrete paving.
 - 2. Stamped concrete paving.
- C. Related Requirements:
 - 1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
 - 2. Section 321313 "Concrete Paving" for cast-in-place concrete paving with other finishes, curbs and gutters, and stamped detectable warnings.
 - 3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within decorative concrete paving and in joints between decorative concrete paving and other paving or adjacent construction.

1.2 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.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to decorative concrete paving, including but not limited to, the following:
 - a. Concrete mixture design.
 - b. Quality control of concrete materials and decorative concrete paving construction practices.
 - 2. Require representatives of each entity directly concerned with decorative concrete paving to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Decorative concrete paving Installer.
 - e. Manufacturer's representative of decorative concrete paving system.

1.4 ACTION SUBMITTALS

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

- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration: For each product.
 - 2. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color, pattern, or texture selection.
- D. Samples for Verification: For each type of exposed color, pattern, or texture indicated.
- E. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer, 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.
- C. Material Test Reports: For each of the following:
 - 1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- D. Qualification Data: For Installer and testing agency.
- E. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers licensed, trained and approved by manufacturer of decorative concrete paving systems.
 - 1. Provide letter of certification from decorative concrete paving manufacturer stating that installer is a licensed applicator of special concrete finishes and is familiar with proper procedures and installation requirements of the manufacturer.
 - 2. Use an authorized decorative concrete paving licensed contractor and adequate number of skilled workmen who are thoroughly trained and experienced in the necessary craft.
 - 3. Applicator shall be familiar with the specified requirements and the methods needed for proper performance of work of this section.
- B. 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").
- C. 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.
- D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 1. Build mockups of full-thickness sections of decorative concrete paving to demonstrate typical joints; surface color, pattern, and texture; curing; and standard of workmanship.
 2. Build mockups of decorative concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than **96 inches** by **96 inches**.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on decorative concrete paving mixtures.

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**, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than **50 deg F** and not more than **80 deg F** 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** and as follows when hot-weather conditions exist:
 1. Cool ingredients before mixing to maintain concrete temperature below **90 deg F** at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: The design for the decorative concrete paving is based on the product named. Subject to compliance with requirements, provide either the named product or an approved equal product by another qualified manufacturer.
 1. The Bomanite Company; Bomanite Revealed, Custom Colors (Limestone Gray and Charcoal Gray).

2.2 CONCRETE, GENERAL

- A. ACI Publications: Comply with **ACI 301** unless otherwise indicated.

2.3 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 of a radius of **100 feet** or less. Do not use notched and bent forms.
- B. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.
- C. 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.

2.4 STEEL REINFORCEMENT

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- B. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from as-drawn steel wire into flat sheets.
- C. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60**; deformed.
- D. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, **Grade 60** deformed bars; assembled with clips.
- E. Plain-Steel Wire: ASTM A 1064/A 1064M, as drawn.
- F. Joint Dowel Bars: ASTM A 615/A 615M, **Grade 60** plain-steel bars. Cut bars true to length with ends square and free of burrs.

- G. 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.

2.5 CONCRETE MATERIALS

- A. Regional Materials: Concrete shall be manufactured within 100 miles of Project site from aggregates and cementitious materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.
- B. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- C. Cementitious Materials:
 - 1. Engineered Cement Binder: Cementitious hardener comprised of specialty cements.
 - a. Basis-of-Design Product: The Bomanite Company; Bomanite Revealed Concentrate.
 - 2. Portland Cement: ASTM C 150/C 150M, white portland cement Type I or Type III.
 - 3. Fly Ash: ASTM C 618, Class C or F.
 - 4. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
- D. Normal-Weight Aggregates: ASTM C 33/C 33M, 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 inch nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
 - 3. Decorative Aggregates: Granite, quartz, or other natural stone aggregates as required to match Architect's sample.
- E. Air-Entraining Admixture: ASTM C 260/C 260M.
- F. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not 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.
 - a. Basis-of-Design Product: The Bomanite Company; Bomanite Deactivator.
 - 3. Water-Reducing and Accelerating Admixture: ASTM C 494/C 494M, Type E.
- G. Color Pigment: ASTM C 979/C 979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

1. Basis-of-Design Product: The Bomanite Company; Bomanite Revealed Tint Packs.

H. Water: Potable and complying with ASTM C 94/C 94M.

2.6 FIBER REINFORCEMENT

- A. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C 1116/C 1116M, Type III, **1/2 to 1-1/2 inches** long.

2.7 SURFACE COLORING MATERIALS

- A. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

2.8 STAMPING DEVICES

- A. Stamp Mats: Semirigid polyurethane mats with projecting textured and ridged underside capable of imprinting texture and joint patterns on plastic concrete.
- B. Stamp Tools: Open-grid, aluminum or rigid-plastic stamp tool capable of imprinting joint patterns on plastic concrete.
- C. Rollers: Manually controlled, water-filled aluminum rollers with projecting ridges on drum capable of imprinting texture and joint patterns on plastic concrete.
- D. Texture Rollers: Manually controlled, abrasion-resistant polyurethane rollers capable of imprinting texture on plastic concrete.

2.9 LIQUID SLAB TREATMENTS

- A. Penetrating Liquid Slab Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

1. Basis-of-Design Product: The Bomanite Company; Bomanite Con-Shield.

2.10 CURING AND SEALING MATERIALS

- A. Curing Paper: Nonstaining, waterproof paper, consisting of two layers of kraft paper cemented together and reinforced with fiber, and complying with ASTM C 171.
- B. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
- C. Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type I, Class B, manufactured for colored concrete.
 1. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
 2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

- D. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type I, Class A, manufactured for use with colored concrete.
- E. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type I, Class A, manufactured for use with colored concrete.
- F. Clear Acrylic Sealer, Low-to-Medium Gloss: Manufacturer's standard, waterborne, non-yellowing and UV-resistant, membrane-forming, acrylic copolymer emulsion or epoxy-modified acrylic emulsion, manufactured for colored concrete, containing not less than 15 percent solids by volume.
 - 1. Basis-of-Design Product: The Bomanite Company; Bomanite HydroLock.
- G. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving surface.

2.11 RELATED MATERIALS

- A. Joint Fillers: ASTM D 1752, cork or self-expanding cork 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. Polyethylene Film: ASTM D 4397, **1 mil** thick, clear.

2.12 CONCRETE MIXTURES

- A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide concrete of consistent quality in appearance and physical properties.
- B. Prepare design mixtures, proportioned according to **ACI 301**, 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.
- C. 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.
- D. 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: 6 percent plus or minus 1.5 percent for 1-inch nominal maximum aggregate size.
- E. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- F. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 1. Use water-reducing and retarding admixture in concrete as required for placement and workability.
 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- G. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd..
- H. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.
- I. Concrete Mixtures: Normal-weight concrete.
 1. Compressive Strength (28 Days): 4500 psi.
 2. Maximum W/C Ratio at Point of Placement: 0.45.
 3. Slump Limit: 5 inches, plus or minus 1/2 inch.

2.13 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, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

- B. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.
 - 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to **3 mph**.
 - 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than **15 tons**.
 - 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of **1/2 inch** according to requirements in Section 312000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.
- B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

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 STEEL REINFORCEMENT INSTALLATION

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum **2-inch** overlap to adjacent mats.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 2. Butt Joints: Use bonding agent or epoxy-bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 3. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least **1-1/2 inches** into concrete.
 4. 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, walks, other fixed objects, and where indicated.
 1. Locate expansion joints at intervals of **50 feet** unless otherwise indicated.
 2. Extend joint fillers full width and depth of joint.
 3. Terminate joint filler not less than **1/2 inch** or more than **1 inch** below finished surface if joint sealant is indicated.
 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent decorative concrete paving:
 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a **1/4-inch** radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
 - a. Tolerance: Ensure that grooved joints are within **3 inches** either way from centers of dowels.
 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut **1/8-inch**-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - a. Tolerance: Ensure that sawed joints are within **3 inches** in both directions from centers of dowels.
 3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a **1/4-inch** radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with **ACI 301** requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to **ACI 301** by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, 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.

3.7 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.

3.8 INTEGRALLY COLORED CONCRETE FINISH

- A. Integrally Colored Concrete Finish: After final floating, apply the following finish:
 - 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.

3.9 PIGMENTED MINERAL DRY-SHAKE HARDENER APPLICATION

- A. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surfaces according to manufacturer's written instructions and as follows:
1. Uniformly apply dry-shake hardener at a rate of **100 lb/100 sq. ft.** unless greater amount is recommended by manufacturer to match paving color required.
 2. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.
 3. After final power floating, apply the following finish:
 - a. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
 - b. 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.
 - c. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface **1/16 to 1/8 inch** deep with a stiff-bristled broom, perpendicular to line of traffic.

3.10 STAMPING

- A. Mat Stamping: After floating and while concrete is plastic, apply mat-stamped finish.
1. Pigmented Powder Release Agent: Uniformly distribute onto concrete at a rate of **3 to 4 lb/100 sq. ft.**
 2. Liquid Release Agent: Apply liquid release agent to the concrete surface and the stamp mat. Uniformly mist surface of concrete at a rate of 5 gal/1000 sq. ft..
 3. After application of release agent, accurately align and place stamp mats in sequence.
 4. Uniformly load mats and press into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp mats. Hand stamp edges and surfaces unable to be imprinted by stamp mats.
 5. Remove residual release agent according to manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.
- B. Tool Stamping: After floating and while concrete is plastic, apply tool-stamped finish.
1. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends **3 inches**, and secure to edge forms. Lightly broom surface to remove air bubbles.
 2. Accurately align and place stamp tools in sequence and tamp into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp tools. Hand stamp edges and surfaces unable to be imprinted by stamp tools.
 3. Carefully remove polyethylene film immediately after tool stamping.
- C. Roller Stamping: After floating and while concrete is plastic, apply roller-stamped finish.
1. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends **3 inches**, and secure to edge forms. Lightly broom surface to remove air bubbles.
 2. Accurately align roller and perform rolling operation to produce required imprint pattern and depth of imprint on concrete surface. Hand stamp surfaces inaccessible to roller.

3. Carefully remove polyethylene film immediately after roller stamping.

3.11 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** 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 Compound: Apply immediately after final finishing. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.
 1. Cure integrally colored concrete with a curing compound.
 2. Cure concrete finished with pigmented mineral dry-shake hardener with a curing compound.
- F. Curing and Sealing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating, and repair damage during curing period.
- G. Curing Paper: Cure with unwrinkled curing paper in pieces large enough to cover the entire width and edges of slab. Do not lap sheets. Fold curing paper down over paving edges and secure with continuous banks of earth to prevent displacement or billowing due to wind. Immediately repair holes or tears in paper.

3.12 SEALER APPLICATION

- A. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat, using same application methods and rates.
 1. Begin sealing dry surface no sooner than 14 days after concrete placement.
 2. Allow stained concrete surfaces to dry before applying sealer.
 3. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.

3.13 PAVING TOLERANCES

- A. Comply with tolerances in **ACI 117** and as follows:
 1. Elevation: **3/4 inch**.

2. Thickness: Plus **3/8 inch**, minus **1/4 inch**.
3. Surface: Gap below **10-foot-long**, unleveled straightedge not to exceed **1/2 inch**.
4. Lateral Alignment and Spacing of Dowels: **1 inch**.
5. Vertical Alignment of Dowels: **1/4 inch**.
6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: **1/4 inch per 12 inches** of dowel.
7. Joint Spacing: **3 inches**.
8. Contraction Joint Depth: Plus **1/4 inch**, no minus.
9. Joint Width: Plus **1/8 inch**, no minus.

3.14 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing 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 **100 cu. yd.** 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** and below and when it is **80 deg F** 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**.
- 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. Decorative 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.

3.15 REPAIR AND PROTECTION

- A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.
- C. Protect decorative 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 decorative 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.

3.16 DECORATIVE CONCRETE PAVING SCHEDULE

- A. Patterned Decorative Concrete Paving:
 - 1. Locations: Install at walks where indicated.
 - 2. Coloring Method: Integrally colored or pigmented mineral dry-shake hardener.
 - a. Color: Match Architect's sample.
 - 3. Field Patterning Method: Stamped.
 - a. Texture and Pattern: Exposed decorative aggregate finish, with running bond pattern and herringbone pattern, as indicated on Drawings.
 - b. Pigmented Mineral Dry-Shake Hardener: Match Architect's sample.
 - c. Release Agent: Match pigmented mineral dry-shake hardener.
 - 4. Border and Accent Strip Patterning Method: Stamped.
 - a. Texture and Pattern: Exposed decorative aggregate finish, and sawed joints pattern, as indicated on Drawings.
 - b. Pigmented Mineral Dry-Shake Hardener: Match Architect's sample.
 - c. Release Agent: Match pigmented mineral dry-shake hardener.

END OF SECTION 321316

SECTION 321400 - UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Precast concrete pavers.
 - 2. Precast concrete tiles.
- C. Related Requirements:
 - 1. Division 32 Section "Asphalt Paving" for asphalt base under unit pavers.
 - 2. Division 32 Section "Concrete Paving" for concrete base under unit pavers.
 - 3. Division 32 Section "Porous Unit Paving" for unit paving using grid pavers or pavers with openings between them.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For materials other than water and aggregates.
 - 2. For the following:
 - a. Pavers.
 - b. Edge restraints.
- B. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C136.
- C. Samples for Initial Selection: For each type of unit paver indicated and the following:
 - 1. Joint materials involving color selection.
 - 2. Exposed edge restraints involving color selection.
- D. Samples for Verification: For full-size units of each type of unit paver indicated.
 - 1. Joint materials.
 - 2. Exposed edge restraints.
- E. Unit Paving Shop Drawings: Include point of beginning, plans, elevations, sections and details:
 - 1. Dimensions of each unit paver type, size, and finish of exposed faces.
 - 2. Unit paver layout showing position and identifying number of each unit paver type & size
 - 3. Cutting & drilling details for any lights, bollards, grates, jets, nozzles, recesses, plumbing, steps, corners, rails, posts and the like.

4. Paving expansion joint layout: plan showing layout of expansion and/or isolation joints within parameters specified and based on the as-built conditions of the substrate.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.
- C. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.
- D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
 1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C67.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified unit paving installer. Installer's field supervisor must have Concrete Paver Installer Certification from the Interlocking Concrete Pavement Institute (ICPI) with one of the following designations:
 1. Commercial Paver Technician Designation.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 1. Install a 10 ft x 10 ft paver area following the installation practices described in Part 3: Execution. This area will be used to verify the full pavement assembly including, but not limited to, joint sizes, joint filler, sand, sand base setting bed, surcharge of bedding sand layer, expansion joints; edge restraints; lines; laying pattern(s); color(s); and texture of the job.
 2. To provide a proper representation of color blend, blending during installation of sample mock-up will be pulled from a minimum of 3 cubes.
 3. If proposed paving color pattern is random, build mock-up of at least 4 paving combinations for type and color in a panel (10 sq ft).
 4. Subject to approval by the Owner, the mock-up may be retained as part of the finished work. If mock-up is not retained, remove and dispose of mock-up.
 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 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 aggregates where grading and other required characteristics can be maintained and contamination avoided.

1.7 FIELD CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 PRECAST CONCRETE PAVERS

- A. Concrete Pavers, Solid Paving Units, Normal-Weight Concrete: Solid paving units made from normal-weight concrete with a compressive strength not less than 6000 psi (41 MPa), water absorption not more than 5 percent according to ASTM C140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67.
 - 1. Thickness: As indicated on Drawings for each paver type.
 - 2. Face Size and Shape: As indicated on Drawings.
 - 3. Color: As indicated by manufacturer's designations.

2.3 PRECAST CONCRETE TILE

- A. Concrete Pavers, Solid Paving Units, Normal-Weight Concrete: Solid paving units made from normal-weight concrete with a compressive strength not less than 6000 psi (41 MPa), water absorption not more than 5 percent according to ASTM C140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67.
 - 1. Thickness: As indicated on Drawings for each paver type.
 - 2. Face Size and Shape: As indicated on Drawings.
 - 3. Color: As indicated by manufacturer's designations.

2.4 CURBS AND EDGE RESTRAINTS

- A. Provide curbs and edge restraints indicated on Drawings.

2.5 ACCESSORIES

- A. Compressible Foam Filler: Preformed strips complying with ASTM D1056, Grade 2A1.

2.6 AGGREGATE SETTING-BED MATERIALS

- A. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.

- B. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing **No. 16 (1.18-mm)** sieve and no more than 10 percent passing **No. 200 (0.075-mm)** sieve.
 - 1. Provide sand of color needed to produce required joint color.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

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.
 - 1. For concrete pavers, a block splitter may be used.
- D. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
- E. Joint Pattern: As indicated.
- F. Tolerances:
 - 1. Do not exceed **1/32-inch (0.8-mm)** unit-to-unit offset from flush (lippage) or **1/8 inch in 10 feet (3 mm in 3 m)** from level, or indicated slope, for finished surface of paving.
- G. Expansion and Control Joints:
 - 1. Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated. Install joint filler

before setting pavers. Sealant materials and installation are specified in Division 07 Section "Joint Sealants."

- H. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
 - 1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
- I. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.
 - 1. Where pavers set in mortar bed are indicated for steps constructed adjacent to pavers set in aggregate setting bed, install steps and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.

3.4 AGGREGATE SETTING-BED APPLICATIONS

- A. Place leveling course and screed to a thickness of indicated on Drawings, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.
- B. Treat leveling course with herbicide to inhibit growth of grass and weeds.
- C. Set pavers with a minimum joint width of **1/16 inch (1.5 mm)** and a maximum of **1/8 inch (3 mm)**, 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.
- D. 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.
- E. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.
- F. Do not allow traffic on installed pavers until sand has been vibrated into joints.
- G. Repeat joint-filling process 30 days later.

3.5 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.
- B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.
- C. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.
 - 1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.
 - 2. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

END OF SECTION 321400

SECTION 321540 - CRUSHED STONE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Crushed stone surfacing.
 - 2. Steel edge restraints.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For materials other than water and aggregates.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration: For each product.
 - 2. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C136.
- D. Samples for Verification: For full-size units of each type of material indicated. Include Samples of the following:
 - 1. Exposed edge restraints.

1.4 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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

1.6 FIELD CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace crushed stone surfacing work damaged by frost or freezing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of crushed stone surfacing material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 CRUSHED STONE SURFACING MATERIALS

- A. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D2940/D2940M, base material.
- 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** sieve, maximum; ASTM D4751.
 - 3. Permittivity: 0.02 per second, minimum; ASTM D4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure, ASTM D4355.
- C. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

2.3 EDGE RESTRAINTS

- A. Steel Edge Restraints: Manufacturer's standard painted steel edging **3/16 inch** thick by **6 inches** high with loops pressed from or welded to face to receive stakes at **36 inches** o.c. and steel stakes **15 inches** long for each loop.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Border Concepts, Inc.
 - b. Collier Metal Specialties, Inc.
 - c. J. D. Russell Company (The).
 - 2. Color: Black.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces indicated to receive crushed stone surfacing, 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. Proof-roll prepared subgrade according to requirements in Section 312000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with crushed stone surfacing installation only after deficient subgrades have been corrected and are ready to receive crushed stone surfacing.

3.3 INSTALLATION, GENERAL

- A. Tolerances: Do not exceed **1/4 inch in 10 feet** from level, or indicated slope, for finished surface of crushed stone surfacing.
- B. Provide edge restraints as indicated. Install edge restraints before placing crushed stone surfacing.
 - 1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after crushed stone surfacing installation.
 - 2. For metal edge restraints with top edge exposed, drive stakes at least **1 inch** below top edge.

3.4 CRUSHED STONE SURFACING INSTALLATION

- A. Compact soil subgrade uniformly to at least 95 percent of ASTM D698 laboratory density.
- B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Place separation geotextile over prepared subgrade, overlapping ends and edges at least **12 inches**.
- D. Place aggregate base, compact by tamping with plate vibrator, and screed to depth indicated.
- E. Treat base course with herbicide to inhibit growth of grass and weeds.

3.5 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace crushed stone surfacing that is loose or otherwise damaged. Provide new crushed stone surfacing to match adjoining crushed stone surfacing and install in same manner as original crushed stone surfacing, with no evidence of replacement.

END OF SECTION 321540

SECTION 323300 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Bicycle racks.
 - 2. Trash receptacles.
 - 3. Bollards.
- C. Related Requirements:
 - 1. Division 03 Section "Cast-in-Place Concrete" for installing concrete footings and concrete seating.
 - 2. Division 31 Section "Earth Moving" for excavation for installing concrete footings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, finishes, field-assembly requirements, and installation details.
- B. Shop Drawings: For each type of site furnishing. Include plans, elevations, sections, details, and attachment to other work.
 - 1. Detail site furnishings and indicate dimensions, method of field assembly, components, and location and size of each field connection.
 - 2. Installation Methods: Show installation methods for site furnishings, including attachment to concrete footings.
- C. Setting Drawings: For anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors that are to be embedded in concrete.
- D. Samples for Verification: For each type of exposed finish, not less than **6-inch-** long linear components and **4-inch-** square sheet components.
 - 1. Include full-size Samples of bicycle rack, trash receptacle. Approved samples may be incorporated into the Work.
- E. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For site furnishings to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 BICYCLE RACKS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the following product or a comparable product by another qualified manufacturer:
 - 1. Landscape Forms; Ring Bike Rack.
- B. Bicycle Rack Construction:
 - 1. Frame: Stainless steel.
 - a. Tubing OD: Not less than 1-1/2 inches.
 - 2. Style: Double-side parking.
 - a. Overall Height: 27-1/4 inches.
 - b. Overall Width: 24-3/4 inches.
 - c. Overall Depth: 1-1/2 inches.
 - d. Capacity: Designed to accommodate no fewer than two bicycles.
 - 3. Security: Designed to lock wheel and frame.
 - 4. Installation Method: Cast in concrete.
- C. Stainless Steel Finish: ASTM A480/A480M, No. 4.

2.2 TRASH RECEPTACLES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the following product, or a comparable product by another qualified manufacturer:
 - 1. Landscape Forms; Collect Litter Receptacle, Metro 40 Collection, 23-Gallon, Side-Opening Litter.
- B. Support Frames: Cast aluminum; welded.
- C. Trash Receptacles:
 - 1. Receptacle Shape and Form: As indicated; with opening for depositing trash in side of lid or top.
 - 2. Lids and Tops: Cast aluminum; welded; permanently secured.
 - a. Description: Combination ash sand pan and elevated shallow dome rain-cap lid.
 - 3. Side Opening Diverter: Cast aluminum; welded.
 - 4. Ash Pan: Steel.
 - 5. Surface Mount Base: Cast aluminum; welded.
 - 6. Receptacle Height: 38 inches.
 - 7. Overall Width: 23-1/2 inches.
 - 8. Overall Depth: 11-1/2 inches.
 - 9. Inner Container: Rigid plastic container with drain holes, lift-out handles; designed to be removable and reusable.
 - 10. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
 - 11. Capacity: Not less than 23 gal..

12. Service Access: Fixed lid or top, side access; inner container and disposable liner lift, tilt, or slide-out for emptying; keyed lock with two keys per receptacle.
- D. Aluminum Finish: Color coated.
 1. Color: Match Architect's samples.
- E. Steel Finish: Galvanized and color coated.
 1. Color: Match Architect's samples.
- F. HDPE Color: As indicated by manufacturer's designation.
- G. Graphics: Surface-applied copy, content, and style according to manufacturer's standard.
 1. Copy: Trash.

2.3 BOLLARDS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the following product, or a comparable product by another qualified manufacturer:
 1. Forms+Surfaces; Helio Bollard, Series 600, Non-Illuminated, Model LBHLO-603-N.
- B. Bollard Construction:
 1. Tubing OD: Not less than 6 inches.
 - a. Stainless Steel: Tubes.
 2. Base: Aluminum.
 3. Style: Welded flat stainless steel cap.>.
 4. Overall Height: 40 inches.
 5. Overall Width: 6 inches diameter.
 6. Accessories: J-bolts and stainless steel mounting hardware.
 7. Installation Method: Bolted to cast-in anchor bolts.
- C. Stainless Steel Finish: ASTM A480/A480M, No. 4, with clear nano-silica particle treatment.

2.4 MATERIALS

- A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
 1. Rolled or Cold-Finished Bars, Rods, and Wire: **ASTM B211**.
 2. Extruded Bars, Rods, Wire, Profiles, and Tubes: **ASTM B221**.
 3. Sheet and Plate: **ASTM B209**.
 4. Castings: ASTM B26/B26M.
- B. Steel and Iron: Free of surface blemishes and complying with the following:
 1. Plates, Shapes, and Bars: ASTM A36/A36M.
 2. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
- C. Stainless Steel: Free of surface blemishes and complying with the following:

1. Sheet, Strip, Plate, and Flat Bars: ASTM A240/A240M or ASTM A666.
 2. Tubing: ASTM A554.
- D. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
1. Polyethylene: Fabricated from virgin plastic HDPE resin.
- E. Anchors, Fasteners, Fittings, and Hardware: Stainless steel; commercial quality, concealed, recessed, and capped or plugged.
1. Antitheft Hold-Down Brackets: For securing site furnishings to substrate.
- F. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.
- G. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
1. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.
- H. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

2.5 FABRICATION

- A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
- B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
- C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
- D. Exposed Surfaces: Polished, sanded, or otherwise finished; surfaces smooth, free of burrs, barbs, splinters, and sharpness; edges and ends rolled, rounded, or capped.
- E. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.6 GENERAL FINISH REQUIREMENTS

- A. 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.

2.7 ALUMINUM FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.8 STEEL AND GALVANIZED-STEEL FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.9 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1. Run directional finishes with long dimension of each piece.
 - 2. Directional Satin Finish: ASTM A480/A480M, No 4.
- C. Clear Surface Treatment: Clear nano-silica particle treatment for stainless steel surfaces to provide enhanced protection from weather and graffiti, and to enhance ease of maintenance cleaning.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, 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 manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
- B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
- C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.
- D. Anchor Bolt Setting: Set cast-in support anchor bolts in concrete footing with smooth top. Verify that anchor bolts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold anchor bolts in position during placement and finishing operations until concrete is sufficiently cured.

- E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and **3/4 inch** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.
- F. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

END OF SECTION 323300

SECTION 328400 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Piping, valves, sprinklers, specialties, controls, and wiring for automatic control planting irrigation systems.
 - 2. Fabrication engineering and design of planting irrigation system by Contractor.

1.2 DEFINITIONS

- A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.
- B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
- C. Irrigation Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
- D. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. FRP: Fiberglass-reinforced plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: Include pressure ratings, rated capacities, and settings of selected models for the following:
 - 1. Water regulators.
 - 2. Water hammer arresters.
 - 3. General-duty valves.
 - 4. Specialty valves.
 - 5. Control-valve boxes.
 - 6. Sprinklers.
 - 7. Irrigation specialties.
 - 8. Controllers. Include wiring diagrams.
 - 9. Control cables. Include splice kits and conduit.
 - 10. Backflow preventers.
- B. Shop Drawings: Show planting irrigation system piping, including plan layout, and locations, types, sizes, capacities, and flow characteristics of irrigation system piping components. Include water meters, backflow preventers, valves, piping, sprinklers and devices, accessories, controls,

and wiring. Show areas of sprinkler spray and overspray. Show wire size and number of conductors for each control cable.

- C. Wiring Diagrams: For power, signal, and control wiring.
- D. Fabrication Engineering and Design Submittals: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show piping and major system components. Indicate interface and spatial relationship between piping, system components, adjacent utilities, and proximate structures.
- B. Zoning Chart: Indicate each irrigation zone and its control valve.
- C. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- D. Field quality-control test reports.
- E. Delegated design engineer qualifications.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For planting irrigation systems, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include data for the following:
 - 1. Automatic-control valves.
 - 2. Sprinklers.
 - 3. Controllers.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Installer Qualifications: Engage an Installer, with not less than 5 years experience in the installation of materials specified, and who has completed irrigation systems similar in material, design, and extent to that indicated for this Project with a record of successful in-service performance.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.8 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
 - 2. Do not proceed with interruption of water service without Owner's written permission.

1.9 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate piping and system components with existing underground utilities and structures. The Contractor shall determine the location of existing utilities and coordinate the design and layout of the irrigation system components to prevent interruption of service or damage to them. Minor adjustments in the irrigation system will be permitted to coordinate with existing fixed obstructions with the Owner's permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fabrication Engineering and Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. Provide sprinklers for turf and grass areas, and drip irrigation specialties for other planting areas. Avoid obstructions such as signs and light standards.
- B. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties, unless otherwise indicated:
 - 1. Irrigation Main Piping: 200 psig.
 - 2. Circuit Piping: 150 psig.
 - 3. Drain Piping: 100 psig.
- C. City of Pompano Beach Requirements:
 - 1. A rust-free and rust-resistance, automatic underground irrigation system installed in accordance with requirements of the Building Code, including:
 - a. A rain-sensing cutoff device.
 - b. 100% coverage with 50% overlap.
 - c. Provisions to reuse water wherever practicable and available.
 - 2. Provision of bubblers for new and relocated trees and plans.

PART 3 - Bubblers will be provided for all new and relocated trees and palms.

3.1 PIPES, TUBES, AND FITTINGS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
- B. PVC Pipe: ASTM D1785, PVC 1120 compound, Schedule 40.
 - 1. PVC Socket Fittings, Schedule 40: ASTM D2466.
- C. PVC Pipe: ASTM D1785, PVC 1120 compound, Schedule 80.
 - 1. PVC Socket Fittings, Schedule 80: ASTM D2467.
- D. PVC, Pressure-Rated Pipe: ASTM D2241, PVC 1120 compound, SDR 21 and SDR 26.
 - 1. PVC Socket Fittings, Schedule 80: ASTM D2467.
- E. PE, Controlled OD Pipe: ASTM F771 and ASTM D3035, PE 3408 compound, DR 9 and DR 11.
 - 1. PE Socket Fittings: ASTM D2683.
- F. Transition Fittings: Refer to Division 22 Sections for transition pipe fittings.

3.2 JOINING MATERIALS

- A. Refer to Division 22 Sections for commonly used pipe joining materials.

3.3 GENERAL-DUTY VALVES

- A. Curb Valves: AWWA C800. Include bronze body, ball or ground-key plug, and wide tee head, with inlet and outlet matching piping material.
- B. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," bottom section with base of size to fit over curb valve, and approximately 3-inch diameter barrel.
 - 1. Shutoff Rods: Furnish total of two steel, tee-handle shutoff rods with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.
- C. Copper-Alloy Ball Valves: MSS SP-110, one-piece brass or bronze body with chrome-plated bronze ball, PTFE or TFE seats, and 400-psig minimum CWP rating.
- D. Bronze Globe Valves: MSS SP-80, Class 125, Type 2, with bronze body and nonmetallic disc.
- E. PVC Ball Valves: MSS SP-122, union type, with full-port ball, socket detachable end connectors, and pressure rating not less than 125 psig.

3.4 SPECIALTY VALVES

- A. Bronze Automatic Control Valves: Cast-bronze body, normally closed, diaphragm type with manual flow adjustment, and operated by 24-V ac solenoid.

- B. Plastic Automatic Control Valves: Molded-plastic body, normally closed, diaphragm type with manual flow adjustment, and operated by 24-V ac solenoid.
- C. Automatic Drain Valves: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below **2-1/2 to 3 psig**.
- D. Quick-Couplers: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.
 - 1. Locking-Top Option: Vandal-resistant, locking feature. Include two matching keys.

3.5 CONTROL-VALVE BOXES

- A. Plastic Control-Valve Boxes: Box and cover, with open bottom and openings for piping; designed for installing flush with grade. Include size as required for valves and service.
 - 1. Shape: Square or rectangular.
 - 2. Sidewall Material: PE, ABS, or FRP.
 - 3. Cover Material: PE, ABS, FRP, or polymer concrete.
 - a. Lettering: IRRIGATION VALVE BOX.
- B. Polymer-Concrete Control-Valve Boxes: Box and cover, with open bottom and openings for piping; designed for installing flush with grade. Include size as required for valves and service.
 - 1. Shape: Square or rectangular.
 - 2. Sidewall Material: Polymer concrete with lateral and vertical sidewall design loading of **5000 lb** minimum over **10 by 10 inches** square.
 - 3. Cover Material: Reinforced polymer concrete with cover design loading of **5000 lb** minimum over **10 by 10 inches** square.
 - a. Lettering: IRRIGATION VALVE BOX.
- C. Drainage Backfill: Cleaned gravel or crushed stone, graded from **3/4 inch** minimum to **3 inches** maximum.

3.6 PIPING SPECIALTIES

- A. Water Regulators: ASSE 1003, single-seated, direct-operated, water-pressure regulators, rated for **150-psig** minimum initial-inlet working pressure, with size, flow rate, and inlet and outlet pressures indicated. Include integral factory-installed or separate field-installed Y-pattern strainer that is compatible with unit for size and capacity.
 - 1. **NPS 2** and Smaller: Bronze body with threaded ends.
 - 2. **NPS 2-1/2** and Larger: Bronze or cast-iron body with flanged ends.
 - 3. Interior Components: Corrosion-resistant materials.
- B. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.
- C. Pressure Gages: ASME B40.1. Include **4-1/2-inch** diameter dial, dial range of 2 times system operating pressure, and bottom outlet.

3.7 SPRINKLERS

- A. Description: Brass or plastic housing and corrosion-resistant interior parts designed for uniform coverage over entire spray area indicated, at available water pressure.
 - 1. Flush, Surface Sprinklers: Fixed pattern, with screw-type flow adjustment.
 - 2. Shrubbery Sprinklers: Fixed pattern, with screw-type flow adjustment.
 - 3. Pop-up, Spray Sprinklers: Fixed pattern, with screw-type flow adjustment and stainless-steel retraction spring.
 - 4. Pop-up, Rotary, Spray Sprinklers: Gear drive, full-circle and adjustable part-circle types.
 - 5. Pop-up, Rotary, Impact Sprinklers: Impact drive, full-circle and part-circle types.

3.8 DRIP IRRIGATION SPECIALTIES

- A. Application Pressure Regulators: Brass or plastic housing, **NPS 3/4**, with corrosion-resistant internal parts, and capable of controlling outlet pressure to approximately **20 psig**.
- B. Strainer/Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.
- C. Emitters: PE or vinyl body.
 - 1. Single-Outlet Emitters: To deliver the following flow at approximately **20 psig**:
 - a. Flow: **1/2 gph**.
 - b. Tubing Size: **1/8-inch** minimum ID and **10 feet** long.
 - 2. Multiple-Outlet Emitters: With at least 6 outlets, to deliver the following flow at approximately **20 psig**:
 - a. Flow at Each Outlet: **1/2 gph**.
 - b. Tubing Size: **1/8-inch** minimum ID and **60 feet** long.
 - 3. Outlet Caps: Plastic, for outlets without tubing.
- D. Drip Tubes: **NPS 1/2 minimum**, flexible PE or PVC tubing for emitters and other devices, of length indicated and with plugged end.

3.9 AUTOMATIC-CONTROL SYSTEM

- A. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
 - 1. Material: Molded plastic.
 - 2. Mounting: Freestanding type for concrete-base mounting.
- B. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and two matching keys.
 - 1. Material: Molded plastic.
 - 2. Mounting: Surface type for wall mounting.
- C. Control Transformer: 24-V secondary, with primary fuse.
- D. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.

- E. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate 2 or more times daily.
 - 1. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
 - 2. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
 - 3. Surge Protection: Metal-oxide-varistor type on each station and primary power.
- F. Wiring: UL 493, Type UF-B multiconductor, with solid-copper conductors and insulated cable; suitable for direct burial.
 - 1. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - 2. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
 - 3. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
- G. Concrete Base: Reinforced precast concrete with opening for wiring.

PART 4 - EXECUTION

4.1 EARTHWORK

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.
- C. Install piping and wiring in sleeves under sidewalks, roadways, and parking lots.
 - 1. Install piping sleeves by boring or jacking under existing paving if possible.
- D. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches, to 12 inches below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.
- E. Provide minimum cover over top of underground piping according to the following:
 - 1. Irrigation Main Piping: Minimum depth of 36 inches below finished grade, or not less than 18 inches below average local frost depth, whichever is deeper.
 - 2. Circuit Piping: 12 inches.
 - 3. Drain Piping: 12 inches.
 - 4. Sleeves: 24 inches.
- F. After pipe installation and backfilling operations match finish grade elevations to maintain intended site drainage patterns.

4.2 PREPARATION

- A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

- B. Provide a backflow preventer for the proposed irrigation system at each point of service connection to a potable water supply system.
- C. 1. Point of service connection to water supply system shall be a minimum 2 inch supply water pipe.

4.3 PIPING APPLICATIONS

- A. Install components having pressure rating equal to or greater than system operating pressure.
- B. Piping in control-valve boxes and aboveground may be joined with flanges instead of joints indicated.
- C. Aboveground Irrigation Main Piping: Use the following piping materials for each size range:
 - 1. **NPS 4** and Smaller: Schedule 80, PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
 - 2. **NPS 5** and Larger: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.
- D. Underground Irrigation Main Piping: Use the following piping materials for each size range:
 - 1.
 - 2. **NPS 4** and Smaller: Schedule 40, PVC pipe and socket fittings, and solvent-cemented joints.
 - 3. **NPS 5** and Larger: Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
- E. Circuit Piping: Use any of the following piping materials for each size range:
 - 1. **NPS 2** and Smaller: Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
 - 2. **NPS 2** and Smaller: SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
 - 3. **NPS 2-1/2 to NPS 4**: Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
 - 4. **NPS 2-1/2 to NPS 4**: SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
- F. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.
- G. Drain Piping: Use the following piping materials:
 - 1. All Sizes: Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
- H. Sleeves: Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
- I. Transition Fittings: Use transition fittings for plastic-to-metal pipe connections according to the following:
 - 1. Couplings:
 - a. Underground Piping **NPS 1-1/2** and Smaller: Manufactured fitting or coupling.
 - b. Underground Piping **NPS 2** and Larger: AWWA transition coupling.

2. Fittings:
 - a. Aboveground Piping: Plastic-to-metal transition fittings.
 - b. Underground Piping: Union with plastic end of same material as plastic piping.
3. Transition fittings are specified in Division 22 Sections.

4.4 VALVE APPLICATIONS

- A. Aboveground, Shutoff-Duty Valves:
 1. **NPS 2** and Smaller: Bronze or plastic ball valve.
 2. **NPS 2-1/2** and Larger: Cast-iron, nonrising-stem gate valve.
- B. Underground, Shutoff-Duty Valves: Use the following:
 1. **NPS 2** and Smaller: Curb stop with tee head, curb-stop service box, and shutoff rod.
 2. **NPS 3** and Larger: AWWA cast-iron gate valve with elastomeric gaskets and stem nut, valve box, and shutoff rod.
- C. Underground, Manual Control Valves: Bronze globe valve with control-valve box and valve key.
- D. Control Valves:
 1. **NPS 2** and Smaller: Bronze or plastic automatic control valve.
 2. **NPS 2** and Smaller: Bronze or Plastic ball valve.
 3. **NPS 2-1/2 and NPS 3**: Bronze or plastic automatic control valve.
- E. Drain Valves:
 1. **NPS 1/2 and NPS 3/4**: Bronze or plastic ball valve.
 2. **NPS 1 to NPS 2**: Bronze or plastic ball valve.

4.5 PIPING INSTALLATION

- A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with **NPS 2** or smaller pipe connection.
- G. Install flanges adjacent to valves and to final connections to other components with **NPS 2-1/2** or larger pipe connection.
- H. Install underground thermoplastic piping according to ASTM D2774.
- I. Lay piping on solid subbase, uniformly sloped without humps or depressions.

- J. Install PVC piping in dry weather when temperature is above 40 degrees F. Allow joints to cure at least 24 hours at temperatures above 40 degrees F before testing unless otherwise recommended by manufacturer.
- K. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet.
- L. Water Hammer Arresters: Install between connection to building main and circuit valves in valve box.

4.6 JOINT CONSTRUCTION

- A. Refer to Division 22 Sections for basic pipe joint construction.

4.7 VALVE INSTALLATION

- A. Underground Curb Stops: Install in service box with top flush with grade.
- B. Underground, Manual Control Valves: Install in manual control-valve box.
- C. Control Valves: Install in control-valve box.
- D. Drain Valves: Install in control-valve box.

4.8 SPRINKLER INSTALLATION

- A. Flush circuit piping with full head of water and install sprinklers after hydrostatic test is completed.
- B. Install sprinklers at manufacturer's recommended heights.
- C. Locate part-circle sprinklers to maintain a minimum distance of **4 inches** from walls and **2 inches** from other boundaries, unless otherwise indicated.
- D. Locate part-circle sprinklers to avoid water spray on walls or structures.

4.9 AUTOMATIC-CONTROL SYSTEM INSTALLATION

- A. Install freestanding controllers on precast concrete bases not less than **36 by 24 by 4 inches** thick, and not less than **6 inches** greater in each direction than overall dimensions of controller.
- B. Install control cable in same trench as irrigation piping and at least **2 inches** below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas if irrigation piping is installed in sleeve.

4.10 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Ground equipment according to Division 26 Sections.
- C. Connect wiring according to Division 26 Sections.

- D. 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 and UL 486B.

4.11 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
 - 1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- B. Refer to Division 22 Sections for equipment nameplates and signs.
- C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tape over underground piping, during backfilling of trenches.
- D. Refer to Division 31 Section "Earth Moving" for warning tapes.

4.12 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled 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 test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace units and retest and reinspect as specified above.

4.13 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that controllers are installed and connected according to the Contract Documents.
- C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
- D. Complete startup checks according to manufacturer's written instructions.

4.14 ADJUSTING

- A. Adjust settings of controllers.

- B. Adjust automatic control valves to provide flow rate of rated operating pressure required for each sprinkler circuit.
- C. Adjust sprinklers so they will be flush with, or not more than **1/2 inch** above, finish grade.

4.15 CLEANING

- A. Flush dirt and debris from piping before installing sprinklers and other devices.

4.16 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controller and automatic control valves. Refer to Division 01 Section "Closeout Procedures."

END OF SECTION 328400

SECTION 329113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Planting soils specified by composition of the mixes.
- C. Related Requirements:
 - 1. Division 31 Section "Site Clearing" for topsoil stripping and stockpiling.
 - 2. Division 32 Section "Turf and Grasses" for placing planting soil for turf and grasses.
 - 3. Division 32 Section "Plants" for placing planting soil for plantings.

1.2 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. Imported Soil: Soil that is transported to Project site for use.
- F. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.
- G. 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.
- H. 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."
- I. 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.
- J. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

- K. SSSA: Soil Science Society of America.
- L. 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.
- M. 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.
- N. 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.
- O. USCC: U.S. Composting Council.

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. Include recommendations for application and use.
 - 2. Include test data substantiating that products comply with requirements.
 - 3. Include sieve analyses for aggregate materials.
 - 4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:
 - a. Manufacturer's qualified testing agency's certified analysis of standard products.
 - b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
 - c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration: For each product.
 - 2. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Samples: For each bulk-supplied material, **1-gal.** volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.5 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.

1.6 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.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil and imported soil.
 - 1. Notify Architect seven days in advance of the dates and times when laboratory samples will be taken.
- B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
 - 1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.8 SOIL-SAMPLING REQUIREMENTS

- A. General: Extract soil samples according to requirements in this article.
- B. Sample Collection and Labeling: Have samples taken and labeled by Contractor in presence of Architect, soil scientist (CPSS) certified by SSSA, soil classifier (CPSC) certified by SSSA, soil scientist (RPSS) registered by the National Society of Consulting Soil Scientists, or state-certified, -licensed, or -registered soil scientist under the direction of the testing agency.
 - 1. Number and Location of Samples: Minimum of eight 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.

1.9 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 D698 (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 SERA-6, 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-inch depth of soil.

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 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

- A. Regional Materials: Imported soil, manufactured planting soil, and soil amendments and fertilizers shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

2.2 PLANTING SOILS SPECIFIED BY COMPOSITION

- A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.
- B. Planting-Soil Type 01: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site; modified to produce viable planting soil. Blend existing, on-site surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 1. Ratio of Loose Compost to Soil: 1:4 by volume (20/80% loose compost to soil).
 2. Weight of Lime: As recommended in soil reports from a qualified testing agency.
 3. Weight of Superphosphate: As recommended in soil reports from a qualified testing agency.
 4. Weight of Commercial Fertilizer: As recommended in soil reports from a qualified testing agency.
 5. Weight of Slow-Release Fertilizer: As recommended in soil reports from a qualified testing agency.
- C. Planting-Soil Type 02: Imported, naturally formed soil from off-site sources and consisting of sandy loam soil according to USDA textures; and modified to produce viable planting soil.

1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least **4 inches** deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
 2. Additional Properties of Imported Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 5 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
 3. Unacceptable Properties: Clean soil of the following:
 - a. Unacceptable Materials: 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.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
 - c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding **2 inches** in any dimension.
 4. Amended Soil Composition: Blend imported, unamended soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Soil: 1:4 by volume (20/80% loose compost to soil).
 - b. Weight of Lime: As recommended in soil reports from a qualified testing agency.
 - c. Weight of Superphosphate: As recommended in soil reports from a qualified testing agency.
 - d. Weight of Commercial Fertilizer: As recommended in soil reports from a qualified testing agency.
 - e. Weight of Slow-Release Fertilizer: As recommended in soil reports from a qualified testing agency.
- D. Planting-Soil Type 03: Manufactured soil consisting of manufacturer's basic topsoil, or sandy loam according to USDA textures, blended in a manufacturing facility with sand, stabilized organic soil amendments, and other materials to produce viable planting soil.
1. Additional Properties of Manufacturer's Basic Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 5 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
 2. Unacceptable Properties: Manufactured soil shall not contain the following:
 - a. Unacceptable Materials: 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.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 5 percent by dry weight of the manufactured soil.
 - c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding **1-1/2 inches** in any dimension.
 3. Blend manufacturer's basic soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Soil: 1:4 by volume (20/80% loose compost to soil).
 - b. Volume of Sand: As recommended in soil reports from a qualified testing agency.

- c. Weight of Lime: As recommended in soil reports from a qualified testing agency.
- d. Weight of Superphosphate: As recommended in soil reports from a qualified testing agency.
- e. Weight of Commercial Fertilizer: As recommended in soil reports from a qualified testing agency.
- f. Weight of Slow-Release Fertilizer: As recommended in soil reports from a qualified testing agency.

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: O, with a minimum of 95 percent passing through a No. 8 sieve and a minimum of 55 percent passing through a No. 60 sieve.
- 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. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.
- D. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33/C33M.

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: May include animal waste.
 - 2. Reaction: pH of 5.5 to 8.
 - 3. Soluble-Salt Concentration: Less than 4 dS/m.
 - 4. Moisture Content: 35 to 55 percent by weight.
 - 5. Organic-Matter Content: 30 to 40 percent of dry weight.
 - 6. Particle Size: Minimum of 98 percent passing through a 1-inch sieve.
- B. 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.
- C. 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 BACKFILL SOIL

- A. Blend sand and organic compost in the following percentages to produce approved backfill material:
 - 1. Ratio of Sand to Organic Compost: 2.33:1 (70/30% Sand to Organic Compost).

2.6 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- B. 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.
- C. 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.

PART 3 - EXECUTION

3.1 GENERAL

- A. Place planting soil and fertilizers according to requirements in other Specification Sections.
- B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.
- C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

- A. Excavation: Excavate soil from designated area(s) to a depth of **6 inches** 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 as indicated on the Drawings, but not less than **12 inches**. Remove stones larger than **1-1/2 inches** 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 as indicated on the Drawings, but not less than 8 inches, and not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
 1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
 - a. Mix lime and sulfur with dry soil before mixing fertilizer.
 - b. Mix fertilizer with planting soil no more than seven 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 at least 80 percent of maximum Standard Proctor density according to ASTM D698 and tested in-place.
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 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 as indicated on the Drawings, but not less than 12 inches. Remove stones larger than 1-1/2 inches 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 as indicated on the Drawings, but not less than 8 inches, and 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 at least 80 percent of maximum Standard Proctor density according to ASTM D698.
- 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 as indicated on the Drawings, but not less than **12 inches**. Remove stones larger than **1-1/2 inches** 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 and sulfur with dry soil before mixing fertilizer.
 - 2. Mix fertilizer with planting soil no more than seven days before planting.
- D. Compaction: Compact blended planting soil to at least 80 percent of maximum Standard Proctor density according to ASTM D698.
- 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 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

- A. Application: Apply **4 inches** of compost to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: 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 D698. Space tests at no less than one for each **1000 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.

3.8 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 overcompacted, 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.

3.9 CLEANING

- A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
 1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329113

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Sodding.
 - 2. Turf renovation.
 - 3. Erosion-control material(s).
- C. Related Requirements:
 - 1. Division 32 Section "Soil Preparation" for planting soils.
 - 2. Division 32 Section "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.

1.2 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.
- E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer.
- B. Product Certificates: For fertilizers, from manufacturer.

- C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required maintenance periods.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf and meadow establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
 - 2. Experience: Five years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certifications: Installer's field supervisor shall have certification in all of the following categories from the National Association of Landscape Professionals:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Lawn Care Manager.
 - c. Landscape Industry Certified Lawn Care Technician.
 - 5. Pesticide Applicator: State licensed, commercial.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.
- 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. Spring Planting: March 1 to May 31.
 - 2. Fall Planting: September 1 to October 31.

- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 TURFGRASS SOD

- A. Turfgrass Sod: Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Full Sun: Floratam St. Augustine Grass.
 - 2. Sun and Partial Shade: Floratam St. Augustine Grass.

2.2 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 soil-testing laboratory.
- 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 soil-testing laboratory.

2.3 MULCHES

- A. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

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 Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.
- B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

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 AREA PREPARATION

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place and mix planting soil in place over exposed subgrade.

1. Reduce elevation of planting soil to allow for soil thickness of sod.
- 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 Area Preparation" Article.
- B. 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.
- C. 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 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 1. Lay sod across slopes exceeding 3:1.
 2. Anchor sod on slopes exceeding 6:1 with wood pegs[or steel staples] spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.6 TURF RENOVATION

- A. Renovate existing turf where indicated.
- B. Renovate turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
 1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
 2. Install new planting soil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- D. Remove topsoil containing foreign materials, such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

- E. Mow, dethatch, core aerate, and rake existing turf.
- F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of **6 inches**.
- I. Apply soil amendments and initial fertilizer required for establishing new turf and mix thoroughly into top **4 inches** of existing soil. Install new planting soil to fill low spots and meet finish grades.
 - 1. Soil Amendment(s): Provide according to requirements of Section 329113 "Soil Preparation."
 - 2. Initial Fertilizer: Commercial fertilizer or slow-release fertilizer applied according to manufacturer's recommendations.
- J. Apply seed and protect with straw mulch. or sod, as indicated on the Drawings, as required for new turf.
- K. Water newly planted areas and keep moist until new turf is established.

3.7 TURF MAINTENANCE

- A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep 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 turf with fine spray at a minimum rate of **1 inch** per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow Floratam St. Augustine grass to a height of **3-1/2 to 4 inches**.

- D. Turf Postfertilization: Apply commercial fertilizer or 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.

3.8 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 - 1. Satisfactory Seeded Turf: 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.**
 - 2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.9 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.

3.10 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.

3.11 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
 - 1. Sodded Turf: 30 days from date of Substantial Completion.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide the work of this Section in accordance with requirements of the Contract Documents.
- B. Section includes, but is not limited to:
 - 1. Plants.
 - 2. Tree stabilization.
 - 3. Tree-watering devices.
 - 4. Landscape edgings.
- C. Related Requirements:
 - 1. Division 32 Section "Soil Preparation" for planting soils.
 - 2. Division 32 Section "Turf and Grasses" for turf (lawn) and erosion-control materials.

1.2 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, or if not indicated, diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. 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, or if not indicated, diameter and depth recommended by ANSI Z60.1 for type and size of plant required.
- 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 329113 "Soil Preparation" for drawing designations 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.

1.3 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.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Plant Materials: Include quantities, sizes, quality, and verified sources for plant materials.
 - 2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.
- B. Samples for Verification: For each of the following:

1. Trees and Shrubs: Three Samples of each variety and size delivered to site for review. Maintain approved Samples on-site as a standard for comparison.
2. Organic Mulch: 1-quart volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
3. Weed Control Barrier: 12 by 12 inches.
4. Proprietary Root-Ball-Stabilization Device: One unit.
5. Slow-Release, Tree-Watering Device: One unit of each size required.
6. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
7. Root Barrier: Width of panel by 12 inches.

1.6 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. Plant Sources Data: Provide names and locations of nurseries proposed as sources of acceptable plants, and a list of the plants they will provide.
- C. 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.
- D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.
- E. Sample Warranty: For special warranty.

1.7 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.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 2. Experience: Five years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Horticultural Technician.

5. Pesticide Applicator: State licensed, commercial.
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
 1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.
- 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.
- E. Plant Material Selection: Architect reserves the right to select and observe all plants at the nursery prior to delivery and to reject plants that do not meet specifications as set forth in this specification. If a particular defect or substandard element can be corrected at the nursery, as determined by the Architect, the agreed upon remedy may be applied by the nursery or the Contractor provided that the correction allows the plant to meet the requirements set forth in this specification. Any work to correct plant defects shall be at the Contractor's expense.
 1. The Architect may make invasive observation of the plant's root system in the area of the root collar and the top of the root ball in general in order to determine that the plant meets the quality requirements for depth of the root collar and presence of roots above the root collar. Such observations will not harm the plant.
 2. Corrections are to be undertaken at the nursery prior to shipping.
- F. Plant Sources: Provide names and locations of nurseries proposed as sources of acceptable plants, and a list of the plants they will provide. The plant list shall include the botanical and common name and the size at the time of selection. Observe all nursery materials to determine that the materials meet the requirements of this section.
 1. Trees shall be purchased from the growing nursery. Re-wholesale plant suppliers shall not be used as sources unless the Contractor can certify that the required trees are not directly available from a growing nursery. When Re-wholesale suppliers are utilized, the Contractor shall submit the name and location of the growing nursery from where the trees were obtained by the re-wholesale seller. The re-wholesale nursery shall be responsible for any required plant quality certifications.
 2. The Contractor shall require the grower or re-wholesale supplier to permit the Architect to observe the root system of all plants at the nursery or job site prior to planting including random removal of soil or substrate around the base of the plant. Observation may be as frequent and as extensive as needed to verify that the plants meet the requirements of the specifications and conform to requirements.

3. Each tree shall have a numbered seal applied by the Contractor. The seal shall be placed on a lateral branch on the north side of the tree. The seal shall be a tamper proof plastic seal bearing the Contractors name and a unique seven-digit number embossed on the seal.
 - a. Do not place seals on branches that are so large that there is not sufficient room for the branch growth over the period of the warranty.
4. The Architect may choose to attach his seal to each plant, or a representative sample. Viewing or sealing of plants by the Architect at the nursery does not preclude the Architect's right to reject material while on site. The Contractor is responsible for paying any up charge for the Architect to attach his seal to specific plants.

1.9 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. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.
- D. 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.
- E. Handle planting stock by root ball.
- F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.
- G. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
 1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
- H. 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.
- I. 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.

1.10 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: March 1 to May 31.
 2. Fall Planting: September 1 to October 31.
- 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.

1.11 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 and 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: Six months.
 - c. Annuals: Three 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 each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.
- E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- F. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.
- G. Plant Quality:
 - 1. General: Provide healthy stock, grown in a nursery and reasonably free of die-back, disease, insects, eggs, bores, and larvae. At the time of planting all plants shall have a root system, stem, and branch form that will not restrict normal growth, stability and health for the expected life of the plant.
 - 2. Plant Quality Above the Soil Line:
 - a. Plants shall be healthy with the color, shape, size and distribution of trunk, stems, branches, buds and leaves normal to the plant type specified. Tree quality above the soil line shall comply with the project Crown Acceptance details and the following:

- 1) Crown: The form and density of the crown shall be typical for a young specimen of the species or cultivar pruned to a central and dominant leader.
 - a) Crown specifications do not apply to plants that have been specifically trained in the nursery as topiary, espalier, multi-stem, clump, or unique selections such as contorted or weeping cultivars.
 - 2) Leaves: The size, color, and appearance of leaves shall be typical for the time of year and stage of growth of the species or cultivar. Trees shall not show signs of prolonged moisture stress or over watering as indicated by wilted, shriveled, or dead leaves.
 - 3) Branches: Shoot growth (length and diameter) throughout the crown should be appropriate for the age and size of the species or cultivar. Trees shall not have dead, diseased, broken, distorted, or otherwise injured branches.
 - a) Main branches shall be distributed along the central leader not clustered together. They shall form a balanced crown appropriate for the cultivar/species.
 - b) Branch diameter shall be no larger than two-thirds (one-half is preferred) the diameter of the central leader measured 1-inch above the branch union.
 - c) The attachment of the largest branches (scaffold branches) shall be free of included bark.
 - 4) Trunk: The tree trunk shall be relatively straight, vertical, and free of wounds that penetrate to the wood (properly made pruning cuts, closed or not, are acceptable and are not considered wounds), sunburned areas, conks (fungal fruiting bodies), wood cracks, sap leakage, signs of boring insects, galls, cankers, girdling ties, or lesions (mechanical injury).
 - 5) Temporary branches, unless otherwise specified, can be present along the lower trunk below the lowest main (scaffold) branch, particularly for trees less than 1-inch in caliper. These branches should be no greater than 3/8-inch diameter. Clear trunk should be no more than 40 percent of the total height of the tree.
- b. Trees shall have one central leader. If the leader was headed, a new leader (with a live terminal bud) at least one-half the diameter of the pruning cut shall be present.
 - 1) All trees are assumed to have one central leader trees unless a different form is specified in the plant list or drawings.
 - c. All graft unions, where applicable, shall be completely closed without visible sign of graft rejection. All grafts shall be visible above the soil line.
 - d. Trunk caliper and taper shall be sufficient so that the lower five feet of the trunk remains vertical without a stake. Auxiliary stake may be used to maintain a straight leader in the upper half of the tree.
3. Plant Quality at or Below the Soil Line:
 - a. Plant roots shall be normal to the plant type specified. Root observations shall take place without impacting tree health. Root quality at or below the soil line shall comply with the project Root Acceptance details and the following:
 - 1) The roots shall be reasonably free of scrapes, broken or split wood.
 - 2) The root system shall be reasonably free of injury from biotic (e.g., insects and pathogens) and abiotic (e.g., herbicide toxicity and salt injury) agents. Wounds resulting from root pruning used to produce a high quality root system are not considered injuries.
 - 3) A minimum of three structural roots reasonably distributed around the trunk (not clustered on one side) shall be found in each plant. Root distribution

shall be uniform throughout the root ball, and growth shall be appropriate for the species.

- a) Plants with structural roots on only one side of the trunk (J roots) shall be rejected.
- 4) The root collar shall be within the upper 2-inch of the substrate and soil. Two structural roots shall reach the side of the root ball near the top surface of the root ball. The grower may request a modification to this requirement for species with roots that rapidly descend, provided that the grower removes all stem girdling roots above the structural roots across the top of the root ball.
- 5) The root system shall be reasonably free of stem girdling roots over the root collar or kinked roots from nursery production practices.
 - a) Plant Grower Certification: The final plant grower shall be responsible to have determined that the plants have been root pruned at each step in the plant production process to remove stem girdling roots and kinked roots, or that the previous production system used practices that produce a root system throughout the root ball that meets these specifications. Regardless of the work of previous growers, the plant's root system shall be modified at the final production stage, if needed, to produce the required plant root quality. The final grower shall certify in writing that all plants are reasonably free of stem girdling and kinked roots as defined in this specification, and that the tree has been grown and harvested to produce a plant that meets these specifications.
- 6) At time of observations and delivery, the root ball shall be moist throughout. Roots shall not show signs of excess soil moisture conditions as indicated by stunted, discolored, distorted, or dead roots.

2.2 FERTILIZERS

- A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
 1. Size: 10-gram tablets.
 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.
- B. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per **lb** of vesicular-arbuscular mycorrhizal fungi and 95 million spores per **lb** of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

2.3 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.

2.4 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.
- B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, **4.8 oz./sq. yd..**

2.5 HERBICIDES AND 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.

2.6 TREE-STABILIZATION MATERIALS

- A. Trunk-Stabilization Materials:
 - 1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood or softwood with specified wood pressure-preservative treatment, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal** by length indicated, pointed at one end.
 - 2. Wood Deadmen: Timbers measuring **8 inches** in diameter and **48 inches** long, treated with specified wood pressure-preservative treatment.
 - 3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles.
 - 4. Guys and Tie Wires: ASTM A641/A641M, Class 1, galvanized-steel wire, two-strand, twisted, **0.106 inch** in diameter.
 - 5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
 - 6. Guy Cables: Five-strand, **3/16-inch**-diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of **3 inches** long, with two **3/8-inch** galvanized eyebolts.
 - 7. Flags: Standard surveyor's plastic flagging tape, white, **6 inches** long.
 - 8. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and according to manufacturer's written recommendations.
- B. Root-Ball Stabilization Materials:
 - 1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal** by length indicated; stakes pointed at one end.
 - 2. Wood Screws: ASME B18.6.1.
 - 3. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball and that do not encircle the trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

- C. Palm Bracing: Battens or blocks, struts, straps, and protective padding.
 - 1. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-4-inch nominal** by lengths indicated.
 - 2. Straps: Adjustable steel or plastic package banding.
 - 3. Padding: Burlap.
 - 4. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized in accordance with manufacturer's written instructions unless otherwise indicated.

2.7 LANDSCAPE EDGINGS

- A. Aluminum Edging: Standard-profile extruded-aluminum edging, **ASTM B221**, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Permaloc Corporation.
 - b. Sure-loc Edging Corporation.
 - 2. Edging Size: **3/16 inch** thick by **5-1/2 inches** deep.
 - 3. Stakes: Aluminum, **ASTM B221**, Alloy 6061-T6, approximately **1-1/2 inches** wide by **12 inches** long.
 - 4. Finish: Black anodized.

2.8 TREE-WATERING DEVICES

- A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.
 - 1. Color: As selected by Architect from manufacturer's full range.

2.9 MISCELLANEOUS PRODUCTS

- A. Wood Pressure-Preservative Treatment: AWP A U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.
- B. Root Barrier: Black, molded, modular panels **24 inches** high (deep), **85 mils** thick, and with vertical root deflecting ribs protruding **3/4 inch** out from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.
- C. 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.
- D. Burlap: Non-synthetic, biodegradable.
- E. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTM D448 for Size No. 8.

- F. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

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. 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.

3.3 PLANTING AREA ESTABLISHMENT

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade. Place manufactured planting soil over exposed subgrade.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

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, balled and potted, container-grown, and fabric bag-grown stock.
 3. Excavate at least **12 inches** wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
 4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
 5. 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.
 6. 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.
 7. Maintain supervision of excavations during working hours.
 8. Keep excavations covered or otherwise protected after working hours.
 9. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.
- 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.
1. Hardpan Layer: Drill **6-inch**-diameter holes, **24 inches** apart, into free-draining strata or to a depth of **10 feet**, whichever is less, and backfill with free-draining material.
- 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 VINE 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 flare **1 inch** 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. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about **1 inch** from root tips; do not place tablets in bottom of the hole.
 - a. Quantity: Three for each caliper inch of plant.
 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Balled and Potted and Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare **1 inch** 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. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about **1 inch** from root tips; do not place tablets in bottom of the hole.
 - a. Quantity: Three for each caliper inch of plant.
 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. Fabric Bag-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare **1 inch** above adjacent finish grades.
1. Backfill: Planting soil. For trees, use excavated soil for backfill.
 2. Carefully remove root ball from fabric bag without damaging root ball or plant. 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. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about **1 inch** from root tips; do not place tablets in bottom of the hole.
 - a. Quantity: Three for each caliper inch of plant.
 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- F. Bare-Root Stock: Set and support each plant in center of planting pit or trench with root flare **1 inch** above adjacent finish grade.
1. Backfill: Planting soil. For trees, use excavated soil for backfill.
 2. Spread roots without tangling or turning toward surface. Plumb before backfilling, and maintain plumb while working.
 3. Carefully work backfill in layers around roots by hand. Bring roots into close contact with the soil.
 4. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

5. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside soil-covered roots about **1 inch** from root tips; do not place tablets in bottom of the hole or touching the roots.
 - a. Quantity: Three for each caliper inch of plant.
 6. Continue backfilling process. Water again after placing and tamping final layer of soil.
- G. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 MECHANIZED TREE-SPADE PLANTING

- A. Trees may be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
- B. Use the same tree spade to excavate the planting hole as will be used to extract and transport the tree.
- C. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
- D. Cut exposed roots cleanly during transplanting operations.
- E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.
- F. Where possible, orient the tree in the same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
- C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
- D. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

- A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:
 1. Upright Staking and Tying: Stake trees of **2- through 5-inch** caliper. Stake trees of less than **2-inch** caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least **18 inches** below bottom of backfilled excavation and to extend to the dimension indicated on Drawings, or if not indicated, one-third of trunk

- height above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
2. Upright Staking and Tying: Stake trees with two stakes for trees up to **12 feet** high and **2-1/2 inches** or less in caliper; three stakes for trees less than **14 feet** high and up to **4 inches** in caliper. Space stakes equally around trees.
 3. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
 4. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
- B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than **14 feet** in height and more than **3 inches** in caliper unless otherwise indicated.
1. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.
 - a. Securely attach guys to stakes **30 inches** long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses. Provide turnbuckle for each guy wire and tighten securely.
 - b. For trees more than **6 inches** in caliper, anchor guys to wood deadmen buried at least **36 inches** below grade. Provide turnbuckle for each guy wire and tighten securely.
 - c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - d. Support trees with guy cable or multiple strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - e. Attach flags to each guy wire, **30 inches** above finish grade.
 - f. Paint turnbuckles with luminescent white paint.
 2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
- C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.
1. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of the vertical stakes.
 - a. Install stakes of length required to penetrate at least to the dimension indicated on Drawings, or if not indicated, **18 inches** below bottom of backfilled excavation. Saw stakes off at horizontal stake.
 - b. Install screws through horizontal hold-down and penetrating at least **1 inch** into stakes. Predrill holes if necessary to prevent splitting wood.
 - c. Install second set of stakes on other side of root trunk for larger trees.
 2. Proprietary Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
- D. Palm Bracing: Install bracing system at three or more places equally spaced around perimeter of trunk to secure each palm until established unless otherwise indicated.
1. Site-Fabricated Palm-Bracing Method:

- a. Place battens over padding and secure battens in place around trunk perimeter with at least two straps, tightened to prevent displacement. Ensure that straps do not contact trunk.
 - b. Place diagonal braces and cut to length. Secure upper ends of diagonal braces with galvanized nails into battens or into nail-attached blocks on battens. Do not drive nails, screws, or other securing devices into palm trunk; do not penetrate palm trunk in any fashion. Secure lower ends of diagonal braces with stakes driven into ground to prevent outward slippage of braces.
2. Proprietary Palm-Bracing Device: Install palm-bracing system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.

3.9 ROOT-BARRIER INSTALLATION

- A. Install root barrier where trees are planted within **60 inches** of paving or other hardscape elements, such as walls, curbs, and walkways, unless otherwise indicated on Drawings.
- B. Align root barrier vertically, and run it linearly along and adjacent to the paving or other hardscape elements to be protected from invasive roots.
- C. Install root barrier continuously for a distance of **60 inches** in each direction from the tree trunk, for a total distance of **10 feet** per tree. If trees are spaced closer, use a single continuous piece of root barrier.
 1. Position top of root barrier flush with finish grade, and according to manufacturer's written recommendations.
 2. Overlap root barrier a minimum of **12 inches** at joints.
 3. Do not distort or bend root barrier during construction activities.
 4. Do not install root barrier surrounding the root ball of tree.

3.10 PLACING SOIL IN PLANTERS

- A. Place a layer of drainage gravel at least **4 inches** thick in bottom of planter. Cover bottom with filter fabric and wrap filter fabric **6 inches** up on all sides. Duct tape along the entire top edge of the filter fabric, to secure the filter fabric against the sides during the soil-filling process.
- B. Fill planter with planting soil. Place soil in lightly compacted layers to an elevation of **1-1/2 inches** below top of planter, allowing natural settlement.

3.11 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.

3.12 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 **12 inches** and secure seams with galvanized pins.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Trees and Treelike Shrubs in Turf Areas: Apply organic mulch ring of **3-inch** minimum thickness, unless otherwise indicated on Drawings, with indicated radius around trunks or stems. Do not place mulch within **3 inches** of trunks or stems.
 - 2. Organic Mulch in Planting Areas: Apply **3-inch** minimum thickness, unless otherwise indicated on Drawings, of organic mulch extending **12 inches** beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within **3 inches** of trunks or stems.

3.13 EDGING INSTALLATION

- A. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately **36 inches** apart, driven below top elevation of edging.
- B. Mow-Strip Installation:
 - 1. Excavate for mow strip as indicated on Drawings.
 - 2. Compact subgrade uniformly beneath mow strip.
 - 3. Apply nonselective, pre-emergent herbicide that inhibits growth of grass and weeds.
 - 4. Install aluminum edging, delineating the edge of mow strip.
 - 5. Install weed-control barrier before mulching, covering area of mow strip, and overlapping and pinning edges of barrier at least **6 inches** and according to manufacturer's written instructions.
 - 6. Place indicated thickness of organic mulch, fully covering weed barrier.
 - 7. Rake mulch to a uniform surface level with adjacent finish grades.

3.14 INSTALLING SLOW-RELEASE WATERING DEVICE

- A. Provide one device for each tree.
- B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

3.15 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.

3.16 HERBICIDE AND PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents according to 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. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.17 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. Provide new trees of same size as those being replaced for each tree of **6 inches** or smaller in caliper size.
 - 2. Provide one new tree(s) of **6-inch** caliper size for each tree being replaced that measures more than **6 inches** in caliper size.
 - 3. Species of Replacement Trees: Same species being replaced.

3.18 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.

3.19 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: 12 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: Six months from date of Substantial Completion.

END OF SECTION 329300